DESIGN STRATEGIES INFLUENCING INFORMAL LEARNING IN SCIENCE CENTRE

BY

NURHAYA BINTI BANIYAMIN

A thesis submitted in fulfilment of the requirement for the degree of Doctor of Philosophy (Built Environment)

Kulliyyah of Architecture and Environmental Design
International Islamic University Malaysia

APRIL 2018

ABSTRACT

Museum exhibition environment provides experiential learning through its messages with a view to influence knowledge, attitudes and learning behaviours of visitors. Connections in visitors' cognitive, affective, emotional and physiological responses play a beneficial role in museum visits. The focus of this study is on understanding and enhancing visitors' experience of science centre. Its subject matter is informal learning, situated in the context of both experiential design and exhibition design. The aims of the research are to understand the experiential design strategies that improves science centre intent. The first objective is to determine the tools for enchantment of message in the science centre experience. The second objective is to established the interconnection between science centres' representational systems and the tools for enchantment. The third objective is to explain design opportunities that will improve science centre visitor experience. The theoretical framework is confined to the interrelationship between the concept of atmospheric context, experiential learning, enchantment as a tool of message, representational modes and design opportunities in science centre. The changes in atmospheric context and enchantment are influenced by the design opportunities available in the science centre. Qualitative research methodology namely photographic observation and in-depth interviews were employed to achieve the objectives of the research. The research involves case studies of science centres in Asia pacific. The first finding of the research indicate that the tools for enchantment of message in the science centre experience are thematization, spatialization and scenarization of the experience. The experiential strategies include the spectacular, immersive, ritualized and commercial dimensions. The second finding suggest that design can influence visitor participation with different emphases on three dimensional representations, lighting quality and degree of linearity. The third finding propose design opportunities that improve science centre visitor experience, identified in five main themes: invoking interest, delivering the message, connecting personally, designing inclusive/immersive experience and balancing the constraints. Research conclude that design emphasis increases in complexity to overwhelm, stimulate, and transform, resulting in greater emotional impact that uplifts the level of visitor perception from mere acceptance to motivation and enjoyable learning experience. Well-designed exhibition evokes direct participation and transformational experiences for visitors. The analysis of representative modes on the dimensions of classification, formality and framing revealed the way that visitors are socially constructed as learning subjects. The design of the exhibitions creates a 'model visitor' who is highly motivated to interact with the exhibits and is also autonomous in deciding his/her own learning experiences. The research clarifies that science centre acknowledged the four processes that affect learning: attentional, affective, cognitive and compensatory. The implications from this research are design knowledge which includes connection between science centre offerings, exhibition design emphases, and visitor experiences; the concept of visitor interaction with atmospherics and the exhibition environment; and the design opportunities to improve visitor experiences.

خلاصة البحث

إن بيئة المتحف توفر تعلّماً تجريبيا من خلال رسائله بالنظر إلى التأثير المعرفي، والمواقف والسلوكيات التعلمية للزوار. إن الروابط في استجابات الزوار المعرفية والوجدانية والعاطفية والفسيولوجية تلعب دورًا مُجدياً في زيارة المتاحف. وهذه الدراسة تركز على فهم وتعزيز تجربة الزوار لمركز العلوم. وموضوعها هو التعلم غير الرسمي ، وتكمن في سياق كلٍ من التصميم التجريبي وتصميم المعرض. وتتمثل أهداف البحث في فهم استراتيجيات التصميمات التجريبية التي تعمل على تحسين الغرض من مركز العلوم. والهدف الأول هو تحديد أدوات فن الرسالة في تجربة مركز العلوم. والهدف الثاني هو إقامة الترابط بين أنظمة التمثيل في المراكز العلمية وأدوات التفنن. والهدف الثالث هو شرح فرص التصميم التي من شأنها تحسين تجربة زوار مركز العلوم. ويقتصر الإطار النظري على العلاقة المتبادلة بين مفهوم السياق الجوي ، والتعلم التجريبي ، والتفنن كأداة للرسالة ، وأنماط التمثيل وفرص التصميم في مركز العلوم. إن التغيرات في سياق الغلاف الجوي والافتتان تتأثر بفرص التصميم المتاحة في مركز العلوم. وتم استخدام منهجية البحث النوعي ، أي المراقبة التصويرية والمقابلات المتعمقة لتحقيق أهداف البحث. يتضمن البحث دراسة حالة لمراكز العلوم في آسيا والمحيط الهادئ. وتشير النتيجة الأولى للبحث إلى أن أدوات فن الرسالة في تجربة مركز العلوم هي عبارة عن عمليات تجميع وتوضيح وتصنيف للتجربة. وتشمل الاستراتيجيات التجريبية الأبعاد المثيرة، والغامرة ، والطقوس، والتجارية. وتشير النتيجة الثانية إلى أن التصميم يمكن أن يؤثر على مشاركة الزائرين بتركيزات مختلفة على التمثيل ثلاثي الأبعاد، وجودة الإضاءة ، ودرجة الخطية. وتقترح النتيجة الثالثة فرص التصميم التي تعمل على تحسين تجربة الزائرين في مركز العلوم ، والتي تم تحديدها في خمسة مواضيع رئيسة: استحضار الاهتمام ، وإيصال الرسالة ، والاتصال الشخصي ، وتصميم تجربة شاملة / غامرة ، وتحقيق التوازن بين القيود المفروضة. وتوصل البحث إلى أن التركيز على التصميم يزيد من التعقيد ويطغى على التحفيز والتحول ، مما يؤدي إلى زيادة التأثير العاطفي الذي يرفع مستوى إدراك الزائر من مجرد القبول إلى التحفيز وتجربة التعلم الممتعة. ويستدعي المعرض ذو التصميم الجيد المشاركة المباشرة والخبرات التحويلية للزائرين. وكشف تحليل النمط الممثل لأبعاد التصنيف ، الشكلية والتأطير عن الطريقة التي يتم بها تهيئة الزائرين اجتماعياً كمواضيع تعلم. ويخلق تصميم المعارض "زائراً نموذجياً" له دوافع كبيرة للتفاعل مع المعروضات كما أنه مستقل في تقرير تجاربه التعليمية الخاصة. ويوضح البحث أن مركز العلوم قد أقر العمليات الأربع التي تؤثر على التعلم: النية ، والعاطفة ، والإدراك، والتعويض. والآثار المترتبة على هذا البحث هي المعرفة التصميمية التي تشمل الاتصال بين عروض مركز العلوم ، وتأكيد تصميم المعرض ، وتجارب الزوار ؛ ومفهوم تفاعل الزائرين مع الغلاف الجوي وبيئة المعرض ؛ وفرص التصميم لتحسين تجارب الزوار.

APPROVAL PAGE

The thesis of Nurhaya binti Baniyamin has been approved by the following:

____
Zaiton Abdul Rahim
Supervisor

____
Noor Hanita Abdul Majid
Co-Supervisor

____
Abdul Razak Sapian
Internal Examiner

____
Gurupiah Mursib
External Examiner

____
Abdullah Sani Ahmad
External Examiner

____
Radwan Jamal Yousef Elatrash
Chairman

DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Nurhaya binti Baniyamin

Signature…………………………… Date……………………...

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

DECLARATION OF COPYRIGHT AND AFFIRMATION OF FAIR USE OF UNPUBLISHED RESEARCH

DESIGN STRATEGIES INFLUENCING INFORMAL LEARNING IN SCIENCE CENTRE

I declare that the copyright holder of this thesis are jointly owned by the student and IIUM.

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below

1. Any material contained in or derived from this unpublished research may only be used by others in their writing with due acknowledgement.

2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purpose.

3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

By signing this form, I acknowledged that I have read and understand the IIUM Intellectual Property Right and Commercialization policy.

Nurhaya binti Baniyamin

……………………………… ……………………
Signature Date

This thesis is dedicated to my loving parents.

ACKNOWLEDGEMENTS

All glory is due to Allah, the Almighty, whose Grace and Mercies have been with me throughout the duration of my programme. His continuous Blessings ease the completion of this thesis. Alhamdulillah.

Memorable experience in science centre? People give many answers to this question, most of which share one common feature; an experience towards which one is strongly motivated for future visits. This basic phenomenon led my interest and study to the field of exhibition design and museum experience. Combining two wide subjects - experiential design and informal learning - was not an easy task. My supervisors from the Kulliyyah of Architecture, International Islamic University Malaysia, were able to clarify the context of my work. Associate Professor Dr. Mizanur Rashid crystallised the aim of the study by comments on its design. I would like to thank especially my supervisor Assistant Professor Dr. Zaiton Abdul Rahim for her broad perspective and advice both on the theoretical background and practical methodology of the study. I appreciate her detailed comments, useful suggestions and inspiring queries which have considerably improved this thesis. Comments and suggestions from Associate Professor Dr. Noor Hanita Abdul Majid and Professor Dr. Ar. Abd Razak Sapian made the final thesis much more comprehensive.

Comments on the first outline of this study by Professor Per-Edvin Persson, Director of Heureka, the Finnish Science Centre helped me to find the basic elements of the topic. Intensive discussions with Asger Hoeg, Executive Director of Experimentarium focussed the aim of the study. The theoretical background to science centre education was extended by insightful interview from Cindy Chambers, Head of Concepts and Education at Questacon. The clear ideas of John Richardson, Design and Online Services Manager were of great assistance in the analysis of design planning at Questacon. I would also like to thank Maria Isabel Garcia, the curator of The Mind Museum for encouraging me in this research work despite the very practical demands of managing a new museum. I have also been fortunate to get most valuable criticism on the topic of science centre exhibition from Geoff Snowdon, Director Creative Design at Team Aranda Sdn. Bhd. an expert in the fields. Daniel Tan, Director Exhibitions Group at Science Centre Singapore gave important insight at the beginning of the study. Extensive interviews with Fiona Blades, Exhibition Designer at the Powerhouse Museum and special guided tour with Matthew Connell, Principal Curator Physical Sciences and IT at the Powerhouse Museum is a fortune.

Thanks are also due to the Ministry of Higher Education for economic support for my study, and to the Kulliyyah of Architecture and Environmental Design for accepting this study in their series of Research Thesis. Most gratitude goes to my husband and family for their prayers, understanding and endurance.

Nurhaya binti Baniyamin

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION AND RESEARCH OVERVIEW

1.1 INTRODUCTION

This chapter offers a brief introduction to the context, processes, objectives, specific research questions, significance and potential benefits of this research, as well as an overview of the chapters in this thesis. Details of the research are elaborated from Chapter 2 onwards. The research explained in this thesis focuses on understanding and enhancing visitor experiences in science centre. This research is cross-disciplinary in nature. While its subject matter is informal learning, it is situated in the context of both experiential design and exhibition design.

1.2 BACKGROUND OF STUDY

Science centres are environments for informal learning, a process central to forging knowledge, skills, and positive attitudes about science. Science centres offer visitors exciting opportunities to explore scientific ideas and ways of thinking through fun, interaction and hands-on science exhibits. Most science centre professionals agree that these attractions nurture curiosity, improve motivation and attitudes toward science, engage the visitors through participation as well as social interaction and generate excitement and enthusiasm, all of which are conducive for, science learning and understanding (Anderson and Cook Roe, 1993, Dierking, 1994). Experiences in informal environments for science learning are typically characterized as learner-motivated, guided by learner interests, voluntary, personal, ongoing, contextually relevant, collaborative, nonlinear, and open-ended (Griffin, 1998; Falk and Dierking, 2000). Informal science learning experiences are believed to lead to further inquiry, enjoyment, and a sense that science learning can be personally relevant and rewarding. Participants in them are diverse and include learners of all ages, cultural and socioeconomic backgrounds, and abilities. Ideally these experiences enable learners to connect with their own interests, provide an interactive space for learning, and allow in-depth exploration of current or relevant topics.

Bloom's Taxonomy was created in 1956 under the leadership of educational psychologist Dr Benjamin Bloom to promote higher forms of thinking in education. It is most often used when designing educational, training, and learning processes. The identified three domains of educational activities or learning (Bloom, et al. 1956) are cognitive: mental skills (knowledge), affective: growth in feelings or emotional areas (attitude or self) and psychomotor: manual or physical skills (kinesthetic). This taxonomy of learning behaviours may be thought of as “the goals of the learning process.” That is, after a learning episode, the learner should have acquired a new skill, knowledge, and/or attitude.

Studies document the range of learning that museums afford (Falk, 1999; Leinhard et al., 2002; Rennie and McClafferty, 1996). Within the personal impact category, most studies are concerned with science learning in science centres. Some studies look at the effect of science centre in changing attitudes towards science and leading to the enjoyment of visitors. Other studies of the 1990s periods have demonstrated that students enjoy visits to museums tremendously and that increased interest, attitude and enjoyment of post-visit activities constitute extremely valuable learning outcomes (Anderson, 1999; Ayers and Melear, 1998; Ramey-Gassert et al., 1994).

In the middle of the 1990s, there was wide spread acceptance among researchers of the cognitive, affective and social aspects of the learning experiences of visitors in museums and similar institutions (Raphling and Serrell 1993). Cognitive Learning Theory is a broad theory that explains thinking and differing mental processes and how they are influenced by internal and external factors in order to produce learning in individuals. These cognitive processes are: observing, categorizing, and forming generalizations about our environment. Researchers who embrace cognitive theory prefer to study the learner rather than their environment and in particular the complexities of human memory. A theory of learning that integrates into it the function of motivation is ultimately one that can bring together affective experiences with the construction of meaning. Affective experiences are an essential part of learning, decision making and social functioning (Barrett, Mesquita, Ochsner, & Gross, 2007; Immordino-Yang & Damasio, 2007; and Norman, 2004). Positive affect aids imagination and creativity, while attractive objects (which produce positive affect in the user) are perceived to be easier to use (Norman, 2004). This latter point implies that design can influence positive affect and thus help foster a mind-set that is conducive to discovery, exploration and learning. Further research into relation of exhibition design and learning processes is important to understand the conditions that facilitate an enjoyable and productive learning experience (Packer, 2006).

The social aspects of the learning experiences of visitors in science centres is where learning takes place in the context of meaningful activity and social interaction. Many people visit science centres in family groups. As they talk together, families are observed moving from identifying and describing to interpreting and applying their science centre experiences as evidence that learning is taking place (Anderson and Cook Roe, 1993b, Ramey-Gassert et al., 1994). Science centres are resources for families and schoolchildren, teachers and public. In increasing numbers, science centres are also places where people of all ages, cultures and educational levels can learn at their own pace, engage their curiosity, and use all their senses to ask and answer questions, explore, and explain to others what they have learned.

Science centres are unique educational settings as their design allows visitors to choose the extent and level of their engagement in the different learning opportunities (Falk & Dierking, 2000). Certain visitors may have preferences for certain subject matter, exhibition styles or presentation methods. Scientists and psychologists have developed several different models to understand the different ways that people learn best. One popular theory, the VARK model, identifies four primary types of learners: visual, auditory, reading/writing, and kinesthetic. Each learning type responds best to a different method of teaching. Auditory learners will remember information best after reciting it back to the presenter, while kinesthetic learners prefer to participate in a hands-on activity.

Informal learning in science centre includes, but is not limited to, self-directed learning, discovery or constructivist learning, use or exploration of materials, and interaction with the exhibits or environment. Science Centre emphasis on interactive exhibits and focus on phenomena as opposed to objects. This three-dimensionality of exhibitions, along with the ability to interact with real objects, is particularly significant in a world that is becoming increasingly screen-based (i.e., two-dimensional) in the way that people interact with the world and gain new information and skills (Lord, 2007). "Experiential learning," "constructivist exhibitions," and "hands-on learning," are terms and concepts that have been embraced by museum professionals who create exhibitions. The basics of museum exhibitions in relation to the formation of knowledge began with the Experiential Learning theories (Kolb, 1984). The emphasis is on exploration and reflection besides interaction and environments for learning. Hein (1998) stressed the importance of applying constructivism to museum exhibition design. Constructivist theory argues that both knowledge and the way it is learned are dependent on the minds of learners. Constructivist exhibitions should allow learners to construct their own personal knowledge. Learners mind should be encouraged to manipulate, conjecture, experiment, and draw conclusions of their own without having to conform to an outside standard of truth. Hands-on learning is the concept integrated in the museum programs and exhibitions. This is Dewey's (1933) pedagogical ideas on "learning by doing" that have been applied to the field of museum education.

Bitgood (2002) identified the objectives of informal learning emphasized the quality of experience instead of quantity of learning in formal learning. Enjoyment is measured by verbal descriptions, time at exhibits and repeated visitations. These institutions are predominately viewed by visitors as places for social engagement with family and friends (Morgan & Hodgkinson, 1999). In this free-choice learning environments, visitors largely come by their own choice and are thus intrinsically motivated. Whether visitors choose to interact with exhibits or technology is determined by their own expectations, preferences, and desire to learn (Falk & Dierking, 1992; Hein & Alexander, 1998; and Shettel, 1973). They engage in activities in a self-directed manner, and therefore, their methods of learning are varied (Greenhill, 1999).

Creating interactive exhibitions often requires a team of professionals with diverse backgrounds. While science educators tend to consider visitors' need to learn through different senses and whether the concepts presented are concrete enough to comprehend, designers pay more attention to the ambience of the entire exhibition setting and contemplate how the ambience can have an impact on visitors' perceptual, sensory experiences and level of understanding. As related to exhibition planning, design is the process by which decisions are made regarding all aspects related to how an exhibition will exist and the impact it is intended to have. The word exhibition is generally used throughout this study to reflect a thematically based series of exhibits. The design process includes, but is not limited to exhibition arrangement, mode of presentation, media selection, and setting in relationship to: other media, the space and the visitors. Design is a non-linear, “transactional process involving logic and intuition, in which the message to be communicated, the mode and the medium are played off against one another according to the individual values placed on them” (Miles, et al., 1988).

There is an inseparable association between design and the user experience. Researchers, museums and exhibition designers have recognized the potential of experience design on bringing about improvement and a competitive edge in the field. Design researchers increasingly assume an integrative stance and take the initiative in synthesizing knowledge from diverse domains to generate cross-disciplinary insights regarding experience and identify design opportunities. As noted by Anderson (2004), science centre is an illustration of “reinvented” museum, not only as “keeper of knowledge”, but as a “place of exchange of knowledge”. This is globally defined as part of a logic of enchantment of the experience on offer. Enchantment is a feeling of great pleasure, delight or being captivated. Paradoxically, very little research has focused on the principles of enchantment organized in this cultural sector. In contrast, many studies have been conducted within commercial environments to identify these principles.

1.3 PROBLEM STATEMENT

Museums such as science centre have been changing, offering a wider range of choice. Museums are becoming more hybrid because of increasing cross-fertilization between culture and leisure, and more specifically between museums and amusement parks (MacDonald & Alsford, 1995; and Haywood & Cairns, 2005). The growth of technology has increased the pressure for science centres to update technology in their displays and exhibits. With electronic diversions, science centres find it more difficult to compete for the attention of their visitors. More importantly, science centre must maintain their visitors’ attention by establishing interesting and motivating exhibitions while simultaneously finding ways to fulfil the institutional mission.

The idea of experience provides a clue on symbolic interactions in physical context. Experience is a frequently used word in various academic literatures. Bruner (1986) asserted that experience highlights the critical distinction between reality as what is really out there and experience as how that reality presents itself to consciousness. Throop (2007) suggests it might refer to sensory, perceptual, lived and embodied processes or narrative configured, cognitive, evaluative, mnemonic and expressive forms. Schmitt (1999) proposes that experiences occur as a result of encountering, undergoing or living through things. Thus, the word experience emphasizes primarily active engagement (Sherry et al., 2007 & Kozinets, 2002), knowing through sensory stimuli or psychomotor (Kotler, 1999 & Firat, 2001), and multidimensional stories (Sherry, Kozinets, & Borghini, 2007).

Emotions colour our memories and experiences and thus our selective attention to information (Uzzell & Ballantyne, 1998). There is much emphasis on emotions and creation of emotional intensity as a result of experiencing (Arnould & Price, 1993 and Pullman & Gross, 2004). Yet, emotions are not the only dimension that constitutes an experience. Sensations, cognitive processes, such as in the form of knowledge acquisition, actions, and imaginations also play focal roles (Gupta & Vajic, 2000 and Sundbo & Rasmussen, 2008).

Many researchers view that experience primarily involves combinations of thoughts, senses, and feelings from all kinds of social encounters as a result of interaction between individual processes and the social situation (Abrahams, 1986 and Gupta & Vajic, 2000). An experience is a product that does something to you (entertain, educate or engage), and what you typically walk away with is memory of the encounter (Poulssan & Kale, 2004). Many who have argued that traditionally experience has been approached as the means to an end have cited Van Boven and Gilovich's (2003) explanation for support. According to this perspective, experience plays the role of an instrument in achieving an end, such as satisfaction or happiness felt after the experience, when the subjective evaluation of the experience leads to more positive reinterpretation. Experience has been recognized as a separate offering in the market; and its primary functions are proposed to be entertainment, aesthetics, escape from everyday routine, and learning-edutainment (Pine & Gilmore, 1999 and Wikström, 2008).

The role of exhibition design in orchestrating the content of an exhibition into a holistic experience has received greater recognition since the 1980s (Miles, Alt, Gosling, Lewis & Tout, 1988). There has been greater attention paid to creating experiences, not just displays. Consequently, the role of the exhibition environment including its scale, layout, organisation, lighting, and colour palette has become increasingly recognised as being more than just a passive backdrop or decoration for exhibition content. The role of design of the physical environment may have been underestimated by an emphasis in visitor studies that has left the physical environment unexamined (Roppola, 2012).

In a global scale, over recent decades, there have been significant developments in thinking about how best to engage learners and to optimise their education both in formal and informal settings (Science Centre World Summit 2014). Studies have demonstrated that design decisions can and do have an impact on the visitor experience.

Design can influence visitor flow (Klein, 1993; and Peponis, Dalton, Wineman, & Dalton, 2004); the level and quality of social interactions (Choi, 1999; and Hillier & Tzortzi, 2011); visitor attention (Bitgood & Patterson, 1993); and affective responses (Packer, 2006, 2008). The focus of this study is on understanding and enhancing visitors' experience of science centre. Its subject matter is informal learning, situated in the context of both experiential design and exhibition design. Staging memorable experiences for museum visitors lead visitors to future museum participation and increased learning, appreciation and enjoyment.

A large percentage of visitors are there to kill time, to be entertained, and to satisfy their curiosity (Packer & Ballantyne, 2002). Researchers call for a more in-depth understanding about visitor experiences. The interactive experience model of Falk and Dierking (1992), based on museum experience, shows us that all experience includes the personal, social and the physical context. This model explains that each of these contexts is constructed by the visitor and their interaction creates the visitor's experience.

The making of museum experience is important in nurturing intellectual and emotional benefits in science centre. Various factors can influence learning such as engaging emotions and connecting with prior knowledge and interests. Visitors' motivations and agendas are not fixed; these evolve on an ongoing basis as the visitor interacts with the museum environment (Bitgood, 2011). In many cases, visitors come to museums without specific prior agendas but rather allow themselves to be drawn into learning experiences. For these visitors, following curiosity and learning for learning's sake is what makes museum visits enjoyable.

Packer (2006) described this phenomenon as "Learning for Fun". The factors that support Learning for Fun experiences were found to include: a sense of discovery or fascination; appeal to multiple senses; appearance of effortlessness; and the availability of choice (Packer, 2006). These conditions are all largely independent of specific exhibition content and thus they provide a useful context for further research into understanding, in general terms, how exhibition design may either help or hinder learning processes. There is a need for further research on both the process and outcomes of learning for fun. What features of the learning environment facilitate deeper approaches to learning? It is important that the conditions that facilitate such an experience be understood and provided for visitors who have no particular learning agenda but who can be drawn into a learning experience (Packer, 2006).

The key to enhance science centre as a successful experience for informal learning is in the application of learning research. Visitor experience is a visitor's subjective response to the museum setting, including affective, cognitive and behavioural aspects. Affect is now understood to be an essential part of learning, decision making and social functioning (Barrett, Mesquita, Ochsner, & Gross, 2007; Immordino-Yang & Damasio, 2007; Norman, 2004).

Positive affect aids imagination and creativity, while attractive objects (which presumably produce positive affect in the user) are perceived to be easier to use (Norman, 2004). This latter point suggests that design can influence positive affect and thus help foster a mind-set that is conducive to discovery, exploration and learning. This emotional dimension will inevitably shape the visitor experience (Uzzell & Ballantyne, 1998).

Affect is recognised as an important facet of the visitor experience (Falk & Gillespie, 2009; Packer, 2008; Roppola, 2012; and Soren, 2009). Affect was found to be important in the creation of an overall mental image of the museum (Moreno Gil & Ritchie, 2009). Furthermore, this affective dimension was strongly linked to a motivation of seeking "richness of experience" comprising both entertainment and educational motivations from a museum visit (Moreno Gil & Ritchie, 2009). This suggests a possible link between affective responses and Learning for Fun experiences as described by Packer (2006).

However, the role of the exhibition environment in either enhancing or inhibiting such experiences has not been studied in detail. There is a need to understand the interrelations between learning and the design of learning environments. Furthermore, understanding design opportunities that will improve science centre visitor experience deliberately support learning. This is important because the gap between deeper interpretive contemplation of science phenomena and the experiential pleasure of science exhibits influence visitor interests and future visits.

Pine and Gilmore (1999) describes the shift from a service driven economy to one that values memorable experiences. The authors stress that to deliver a successful experience, it needs to consist of holistic realms (aesthetic, entertainment, education, escapist) which allow flow within the experiential environment. It is the flow that helps one to become immersed and engaged in the event as noted by Csikszentmihalyi (1990). For this reason, experiential elements do not work in isolation; they function as a holistic mechanism in driving the visitor's experience.

The core belief of experiential design is that the needs and desires of users must be central to the design process. Instead of focusing on individual artefacts or the look and feel, designers and researchers are concerned with the quality of people's experiences and devise whole solutions informed by multidisciplinary insights (Margolin, 1997; Shedroff, 2001; Fulton Suri, 2004; and Clark, Smith & Yamazaki, 2006). Limited number of relevant studies on experiential design in science centre implies that there is still much room for design research.

One challenge to furthering our understanding of the exhibition-visitor relationship is a lack of shared knowledge, concepts and vocabulary among exhibition designers, museologists and visitor researchers (Macdonald, 2007). Exhibition design has historically lacked a body of theoretical knowledge to draw upon, with the discipline being mostly practice-led and based on tacit understandings and informal communities of practice (Roppola, 2012). The continuous growth of visitor expectation is another trend that is recognized by the museum field which is not matched with sufficient research. Given the high potential of this scenario, more research effort that focuses on the needs related to experiential design is called for.

1.4 RESEARCH QUESTIONS

Queries are on the kinds of activities supported in the learning place and how the tools for enchantment of experience support forms of thinking. The specific research questions guiding this study are:

1. What are the tools for enchantment of message in the science centre experience?
2. How is the interconnection between its representational systems and enchantment of the science centre experience applied?
3. What are the design strategies that will enhance visitor experiences in science centre?

1.5 RESEARCH OBJECTIVES

The role of the exhibition environment in enhancing learning experiences has not been studied in detail. The research is to understand the experiential design that improves science centre intent. The aim of the research is to investigate the design strategies influencing informal learning in Science Centre. The research is to determine the interrelations between learning and the design of learning environments. What are the design strategies that will improve science centre visitor experience in deliberately support learning? The research is to determine the areas where science centre theme of connections, sensory experience, active engagement, imagination, risk-taking and perceptivity is applied. Understanding how and why these science centres make certain design decisions will provide insight into how this foster visitor participation and immersion. In a world exponentially increasing in the use of media and technology, education and entertainment are becoming more frequently combined to provide "edutainment." It looks at how these edutainment offers, which deliberately adopt enchantment experiential strategies, are defined and structured.

The research identifies the sources that generate visitor responses, known as the representational modes in the exhibitions. How do the representational modes promote the investigative learning of science in pedagogical functioning? The research is also to explain the decision-making processes of planning and implementing exhibition design and the implications of such decisions with regard to visitor interaction and informal learning in the science centre setting. In an attempt to answer the research questions, the following objectives are sought:

1. To determine the tools for enchantment of message in the science centre experience.
2. To established the interconnection between science centres' representational systems and the tools for enchantment.
3. To explain design strategies that will improve science centre visitor experience.

1.6 SCOPE OF RESEARCH

Due to time and access constraints of conducting in-depth case study analyses of multiple science centres, this study is limited to interpretation and analysis of the data gathered at six selected science centres in the Asia Pacific region. The delimitation in type and quantity of science centre examined provide results specific to these selected case studies. Rather than studying the visitor reaction to technology used in exhibitions, this study focused primarily on the decision-making process of designing science centre from the perspective of those working in these cultural institutions. Data was gathered through interviews with centre administrators and staff (educators, curators, designers). Existing interpretive exhibits or exhibitions in the selected science centre were observed, photographed, noted and reviewed. Photographic medium captures contextual information and integrates visual and interpretive data. Interview sets offered a knowledgeable and accessible group of participants and eluded the difficulties and variable nature of directly soliciting feedback from science centre visitors.

1.7 SIGNIFICANCE OF STUDY

This study provides a useful context for understanding, how exhibition design may either help or hinder learning processes. Findings from the research provide knowledge and understanding of the tools on enhancing visitor experience in an informal learning settings. What features of the learning environment that facilitate deeper approaches to learning? It is important to understand the conditions that facilitate such an experience and provided for visitors who have no particular learning agenda but who can be drawn into a learning experience. This research sheds light on the curatorial and managerial objectives. The conclusion from the research determine the design strategies in enhancing visitor experience and informal learning in science centres. This lead to further research on both the process and outcomes of learning for fun.

1.8 METHODOLOGY BRIEF DESCRIPTION

The research methodology for the study is observation, photographic analysis and in-depth interviews. Preliminary enquiries were conducted to solicit opinions from science centre professionals regarding the issues of experiential design, experience and informal learning in science centres. Initial findings indicate the need to understand the function and design aspects for science centre exhibition design success, new challenges, visitors' needs and high expectations. The literature review was also conducted as part of the work that facilitated the refinement of research focus. The qualitative methodological approach is particularly suitable for discovery-oriented research that aims at exploration and explanation instead of hypothesis testing (Walsh, 2003; David & Sutton, 2004; and Creswell, 2007). The goal of this research is to contribute to design knowledge, it builds theories from inductive analysis based on interpretation of themes that emerge from the data. The research begins by identifying the tools for enchantment of the science centre experience and where these sources occur in science centre servicescape. Next, the interconnection between its representational systems and enchantment of the science centre experience is elaborated. Based on insights from the first two research questions, the research then proceeds towards identification of design opportunities that will enhance visitor experiences in science centre. Purposive sampling is one of the principles of qualitative research that guide this research. The idea behind purposive sampling is to purposively select participants or sites that will best help the researcher understand the problem and the research question. Cases for study are selected because they are information-rich and illuminative. This research focuses on experiential design for science centre visitor have 'data' as open-ended, narrative-rich and contextual in nature. The in-depth interview enables the researcher to collect narrative-rich data in the form of experiential accounts of visitor interaction with the exhibitions. Photographic medium study captures contextual data by direct observation. Qualitative research is inherently flexible in the sense that research procedures and data collection can be "emergent". The inductive analytic approach aims at drawing concepts from the data. In this research, the principle of inductive analysis is applied through the use of coding as the key data analysis technique. Categories or themes for coding emerge from understanding the data instead of being predefined. For the purpose of maintaining reflexivity in this research, notes taking is used to record insights during the research process and reflect on possible bias. Given the role as both researcher and interviewer, all decisions, procedures, and analysis in this study were impacted by the lens through which the researcher view the world and all that happens within it. The researcher past experience - educationally, socio-culturally, and particularly in terms of own perspectives related to museum environments - impact the overall approach to this study, as well as interpretations of the data and understanding of the findings. As typical in qualitative studies, two levels of sampling were necessary: (1) selection of "the case" science centre and (2) selection of participants and items to analyze within the case. Samples of six science centres served as the source of case study for data. These particular science centres were selected purposefully based on several specific criteria (Merriam, 1998) or attributes: size and location, quality of exhibitions, variety of exhibition elements and the range of exhibitions. The final factor for selection was based on "convenience sampling" (Glaser & Strauss, 1967; Merriam, 1998; and Strauss & Corbin, 1990) relative to access. Data collection methods for this study included photographic analysis of the science centres environment and interviews with science centre professionals. Field-based data on science centre physical context are obtained through photographic medium, while broader views about criteria for design success can be solicited through in-depth interviews. Figure 1.1 shows the structure of this thesis.

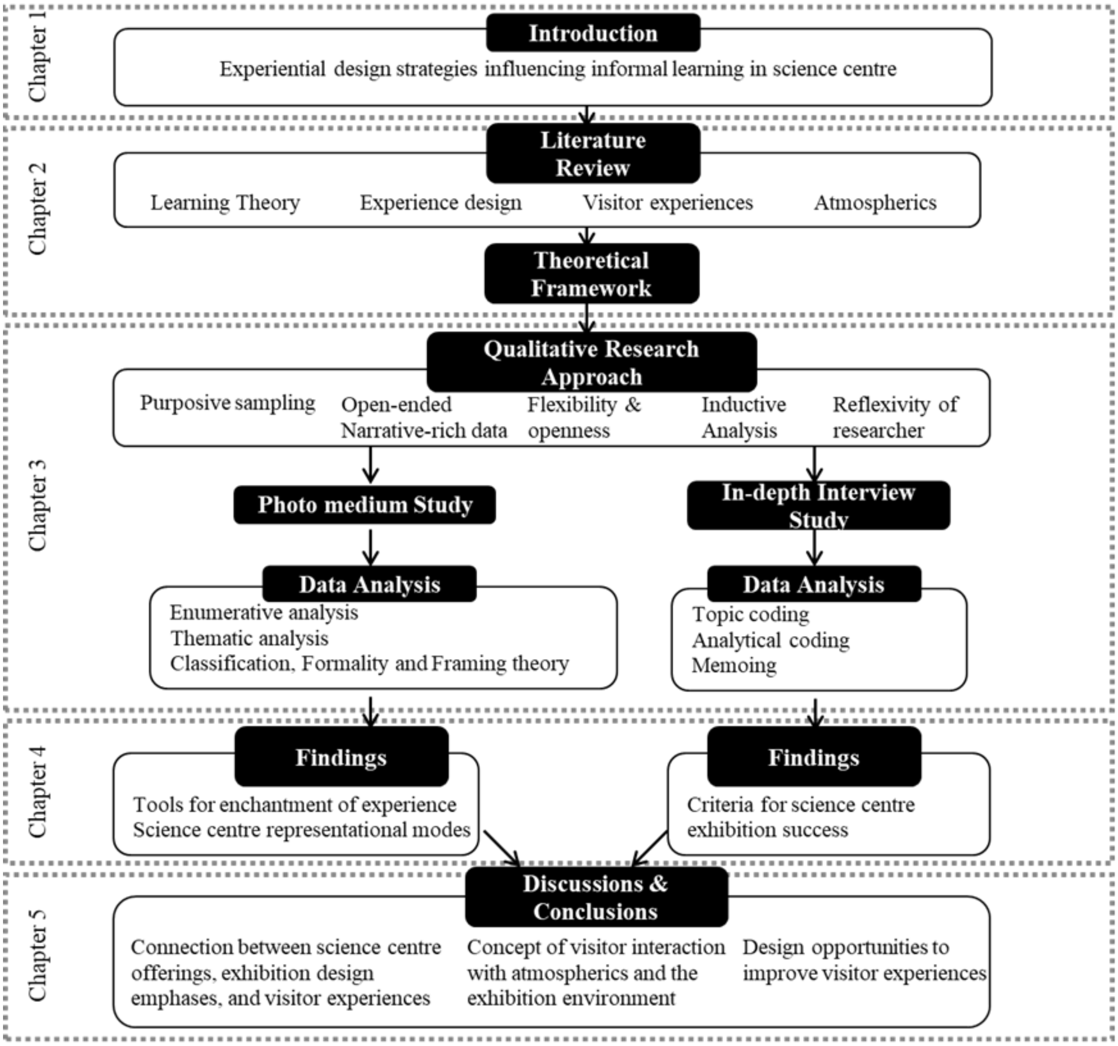


Figure 1.1 Research Structure

1.9 LIMITATIONS

This research has its limitations. This need to be pointed out to qualify the results and identify future avenues for research. The research is limited by the following:

1. This research is limited to interpretation and analysis of the data gathered at six selected science centres. The type and quantity of science centres examined provide results specific to these selected science centres.

2. In terms of research methods used in this research, each method has its own limitations. While photographic medium captures contextual information, and integrates visual and interpretive data, it cannot obtain broader views or experiences beyond exhibition area of particular science centre visits. Also, the photos taken consists of exhibition environment but not events or other social interactions. Another disadvantage is that it is time-consuming to sort and analyze a huge amount of photos.

3. The limitation to the research refers to the mobilization of visual ethnology techniques, the use made of them and the slant they give. By mobilizing ethnographic techniques and leaving a central role for researchers in analyzing the material collected, the risks of over interpretation seem high.

4. As to the in-depth interview method, although it has the strengths of obtaining insights of exhibition design, allowing direct communication, and enabling the researcher to probe into recurring themes in the interviewees' answers, it's obvious limitation is the time spent on the exhibition areas. The degree of details in the data depends on the interviewees' description based on their interpretation. Hence the combination of photo medium and in-depth interview is important. The two methods remedied some of each

other's limitations and keep the data balanced.

5. Another limitation of this research is the betterment of the suggested design opportunities for experiential offerings. This thesis has suggested some design opportunities for exhibition design in science centre. They are incremental improvement instead of radical ones because the design opportunities are suggested on the basis of research findings that reflect the managerial point of view.

6. The initial plan for this research included a more weighted emphasis on how experiential design are integrated into the exhibition. It evolves a quantitative evaluation on the visitor's reactions to their exhibition experience. However, given the diversity among visitors, variation in their expectations upon entering an exhibition, and the difficulty to follow a completely goal-driven approach to all exhibitions relative to all visitors, this study focused primarily on the decision-making process of designing science centre from the perspective of those working in these cultural institutions. For the purposes of this study, diversity represents differences in age, social groups, gender, race or cultural background, economic status, and education level - as well as prior exposure to and reasons for visiting museums (Serrell, 1996).

7. Existing interpretive exhibits or exhibitions in selected science centres were observed, photographed, noted and reviewed. These series of site observations and interview sets offered a knowledgeable and accessible

group of participants and eluded the difficulties and variable nature of directly soliciting feedback from science centre visitors.

8. The selected renowned science centres in this study may not be representative of the process used to design exhibitions at other types of museums. Different cultural institutions may warrant different approaches and objectives, thus leading to different study results and conclusions. Though the findings resulting from this study may offer some transferability and insight into similar settings and situations, they may not be generalizable to all museums settings use.

1.10 ORGANIZATION OF THESIS

This thesis has five chapters. Chapter 1 gives a brief overview of the research including its research context, research processes, research questions, research objectives, as well as its significance and potential benefits. Chapter 2 of this thesis includes a comprehensive review of the relevant literature and the theoretical framework related to the research context. The review includes:

1. A historical review of exhibition environment and learning theories, focusing on the educational concept applied in museums. This will include theoretical models for describing learning experiences and meaning-making that have emerged from informal learning and museum theory.

2. A review on the field of message communication, museum visitor studies literature, experience design and atmospherics as the design of space that encourage specific affective, cognitive and behavioural outcomes.

3. A review on visitors' behaviour in the experiential environments, with an emphasis on the studies of visitors in exhibition spaces.

4. A review on representational systems in the science centre environments situated within theory of epistemological and the pedagogical message of science centre.

Chapter 3 elaborates on the research methods. The chapter begins with explanations on the steps taken to develop the research questions. It then explains on the rationale for selecting the qualitative research approaches and the strategic research principles that guide this research. Two sections describe the key data collection methods of the photographic medium and in-depth interviews including: specific procedures, recruitment of research participants, and characteristics of data. Next, a section that highlights the perspectives in the research design is followed by two sections detailing data analysis procedures, which include theoretical underpinnings, types of analysis and coding. Chapter 4 reports and discusses how this research answered the specific research questions. The research findings are elaborated in three sections. The first two section discuss findings from the photographic medium. They are followed by discussion of the findings from the in-depth interview study in five sections regarding criteria for science centre exhibition success. The conceptual understandings of this research regarding design for visitor experiences are discussed. The chapter concluded with research outcomes that confirm current knowledge, and research outcomes that contribute original insights. Chapter 5 is the final chapter which details the conclusions of this research. Limitations of this research are discussed and directions for future research are also recommended.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 INTRODUCTION

This chapter is divided into two main parts. The first part reviews the related theories on exhibition environment and experiential learning, the message communication process and their inter-relationships. Details on the works reviewed and their implications are elaborated upon in this chapter. The literature review addresses major issues where research in these fields' overlaps and complements. Part of the literature also includes peer-reviewed formal research. This study suggests connections, how visitors' cognitive, affective and psychomotor responses come together and how these interactions play a beneficial role in museum visits. The second part of the chapter focuses on the concept of message and experience design in informal learning of science centre. The value of museum visitor experience which influence visitors' receptivity, formed the theoretical framework of this studies.

2.2 EXHIBITION ENVIRONMENT AND LEARNING THEORIES

The term "exhibition" has multiple meanings and interpretations. Exhibitions can be considered as tools to communicate and persuade; an embodiment of an institution or a representation of brand. From a historiographical perspective, exhibitions can also be seen as products of their time and the assumptions of their creators (Moser, 2010). Over time, exhibitions have evolved to encompass a broader range of media, overlapping with art, advertising, architecture and graphic design. It is thus an orchestration of space, media, content and narrative (Dernie, 2006; Lorenc, Skolnick, & Berger, 2010). The focus of this review will be on the design of interpretive exhibitions (i.e., those with educational, social or aesthetic intent such as those found in museums or other educational leisure settings. In interpretive exhibitions, form and content are increasingly integrated such that the design is as much a mediator of the intended message as the content (Stenglin, 2004).

Exhibition design as a way of intentionally organising and orchestrating the museum visitor experience began to receive greater prominence in the 1980s (Miles, Alt, Gosling, Lewis, & Tout, 1988). While there has been much interest in experiences in the museum, tourism and broader consumption literature, the term itself has been used interchangeably to describe a number of different concepts (Packer, Ballantyne, & Bond, 2013). "Experience" can be a noun or a verb: a product that is marketed and consumed; or a process that unfolds spatially and temporally. In a museum, experience can be seen as a process of mutual interaction or "dialogue" between a visitor and their setting (McCarthy & Ciolfi, 2008). The conception of visitor experience used in this study aligns with the definition as "an individual's immediate subjective and personal response to an activity, setting or event outside their usual environment" (Packer et al., 2013). There has been greater attention paid to creating experiences, not just displays. Consequently, the role of the exhibition environment, including its scale, layout, organisation, lighting, and colour palette has become increasingly recognised as being more than just a passive backdrop or decoration for exhibition content.

Museum exhibition environment communicate its messages with a view to influence knowledge, attitudes and learning behaviours of visitors. The importance of experiential learning and the design of learning environments correspond towards enhancing the informal education. Sociocultural theory emphasizes that meaning emerges in the interplay between individuals acting in social contexts and the mediators - including tools, talk, activity structures, signs and symbol systems. Individuals both shape and are shaped by these mediators (Schauble.et.al, 1997). This focus on mediators is a perspective that is very suitable in museums. This view also emphasizes the importance of culture and environment in every learning context. These general ideas are reflected in the work of both classical theorists (Luria, 1976 & Vygotsky, 1978) and contemporary researchers in human learning (Lave & Wenger, 1991, Falk & Dierking, 1992, and Cobb 1994). Sociocultural theory suggests that understanding a phenomenon entails understanding its development. Thus, understanding learning means studying in detail how it unfolds. This includes queries on the kinds of activities supported in the learning place, and how the tools as well as symbols support forms of thinking. The three main ways which guide learning research in museums are the variability of learning, processes of learning, and the role of learning in personal history and the pursuit of meaning (Schauble.et.al, 1997). These learning research are further categorized into subthemes of (1) learning and learning environments; (2) interpretation, meaning, and explanation; and (3) identity, motivation, and interest. These studies which cross their boundaries are considered important interconnections as they call attention to the relationships among learners and environments in the context of meaning-making.

In relation to science centre, a considerable amount of research has been conducted during the last two decades. This body of research can be distinguished into three prevailing aspects. The first aspect focuses on the cognitive (Falk & Dierking, 1992; Beiers & McRobbie, 1992; and Crane, Nicholson, Chen & Bitgood, 1994) and affective impact (Dierking & Falk, 1994 and Wellington, 1989) of the science centres. The second aspect is related to the analysis of the exhibits' design (Alt & Shaw, 1984; Borun, Massey & Lutter, 1993; Perry, 1993; and Screven, 1990). The third aspect brings under the spotlight the issue of the relationship between the design characteristics of the exhibits and the learning outcomes (both cognitive and attitudinal ones) they produce (Boisvert & Slez, 1995; and Seagram, Patten & Lockett, 1993).

The design of learning environments has not been given much attention in learning research until recent years (Brown,1992). A limited number of studies were conducted about the relationships between visitor learning behaviour and other variables in museum settings. As museum researchers seek alternative approaches in understanding and enhancing learning experience, theme variability of learning has recently become the new research frontier. It articulates the interrelations between learning and the design of learning environments. Important forms of variability for study include the experience, knowledge, and interests that visitors bring to museums; the kinds of activities and pathways in which visitors engage during their visits and the means by which museums contribute to their evolving ways of knowing and responding to the world. Within this theme, the variety of ways in which text, images, models, and activities serve as mediators of and supports for learning. Variability theme regards the design of learning environments and the study of learning as best proceeding hand in hand. The design needs to be motivated by a clear vision of what it means to learn. In order to acknowledge the reliability of the message communication process, it is essential to understand the factors that influence visitors' receptivity. Focus on the tools that are employed in the process of design includes: environments that the visitor enters, activity structures, social interactions, written text, narratives and conversations (Schauble.et.al, 1997).

The premise of a design approach is that understanding how people learn depends on being able to study processes of learning in environments that actually support learning (Brown,1992). Learning theories are conceptual frameworks describing how knowledge is absorbed, processed, and retained during learning. Behaviourists look at learning as an aspect of conditioning and will advocate a system of rewards and targets in education. Educators who embrace cognitive theory believe that the definition of learning as a change in behaviour is too narrow and prefer to study the learner rather than their environment and in particular the complexities of human memory. Those who advocate constructivism believe that a learner's ability to learn relies to a large extent on what he already knows and understands, and the acquisition of knowledge should be an individually tailored process of construction. Transformative learning theory focuses upon the often-necessary change that is required in a learner's preconceptions and world view. Cognitive, emotional, and environmental influences, as well as prior experience, all play a part in how understanding, or a world view, is acquired or changed and knowledge and skills retained.

Knowledge is a familiarity, awareness, or understanding of facts, information, descriptions, or skills, which is acquired through experience or education by learning, perceiving or discovering. Knowledge refer to a theoretical or practical understanding of a subject. It can be implicit (as with practical skill or expertise) or explicit (as with the theoretical understanding of a subject); it can be formal or systematic. Formal learning is learning that takes place within a teacher-student relationship, such as in a school system. The term formal learning is the way it is directed and organized. In formal learning, the learning or training departments set out the goals and objectives of the learning. Informal learning is learning that occurs through the experience of day-to-day situations. Across informal settings, learners may develop awareness, interest, motivation, social competencies and practices. They may develop incremental knowledge, habits of mind and identities that set them on a route to learn more.

In 1956, Bloom edited the first volume of Taxonomy of Educational Objectives: The Classification of Educational Goals, which outlined a classification of learning objectives that has come to be known as Bloom's taxonomy. He has suggested three domains of learning:

1. Cognitive: The mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. The cognitive domain is broken into the following six levels of objectives: Remember, Understand, Apply, Analyze, Evaluate, Create.

2. Affective: A concept used to describe the experience of feeling or emotion. Skills in the affective domain describe the way people react emotionally and their ability to feel other living things' pain or joy. Affective objectives typically target the awareness and growth in attitudes, emotion, and feelings. There are five levels in the affective domain: Receiving, Responding, Valuing, Organizing, Characterizing.

3. Psychomotor: Psychomotor is the relationship between cognitive functions and physical movement. Psychomotor learning is demonstrated by physical skills such as movement, coordination, manipulation, dexterity, grace, strength, speed; actions which demonstrate the fine motor skills such as use of precision instruments or tools.

The result during the past 40 years by researchers have refined earlier theories on the nature of knowing and learning. The relative influence of behaviourist, cognitive, and sociocultural perspectives over time has changed. Each emphasizes different aspects of knowing and learning with differing implications for educational practice and research.

1. Behaviorism describes knowledge as the organized accumulation of stimulus-response associations that serve as components of skills (Thorndike, 1931). People learn by acquiring simple skills which combine to produce more

complex behaviours. Rewards, punishments, and other (mainly extrinsic) factors orient people to attend to relevant aspects of a situation and support the formation of new associations and skills.

2. Cognitive theories, in contrast, focus on how people develop, transform and apply structures of knowledge in relation to lived experience, including the concepts associated with a subject matter discipline (or domain of knowledge) and procedures for reasoning and solving problems. Learners actively construct their understanding by trying to connect new information with their prior knowledge. This theoretical approach generally focuses on individual thinking and learning.
3. Sociocultural theory builds on cognitive perspectives, but emphasizes the cultural origins of human development and explores how individuals develop through their involvement in cultural practices (e.g., Cole, 1996; Heath, 1983; Rogoff, 2003). In this view, individuals develop specific skills, commitments, knowledge, and identity as they become proficient in practices that are valued in specific communities.

All three theoretical perspectives have had some influence on the design of informal environments that support science learning. The purposes and outcomes of science learning in informal environments including: the development of interests and motives, knowledge, affective responses, and identity. Some of the relevant principles for the people-centered frame are encapsulated in How People Learn (National Research Council, 1999). Museum educators integrate learning theories and educational objectives in exhibition design. The four related learning theories in museum exhibition design are:

i. Behaviourism

Most of the criticism of behaviourism has been based on its deterministic nature. It sees human behaviour as a mere result of a response to a stimulus or as the interaction of the individual's characteristics and behaviour, and the environment. This model has been widely applied in museum exhibitions and exhibition design by using the exhibit as a stimulus. This led museum professionals to study exhibit effectiveness in terms of its 'power' to attract and hold visitors' attention (Dierking 1992). John Lock's view of human development was used as the basis for the behaviourist approach. With Watson and Skinner as the most influential figures, behavioural psychologists began with the assumption that much of children's typical behaviour is acquired through conditioning and learning principles. Learnt behaviour is defined as 'a relatively permanent change in behaviour that results from practice or experience' (Vasta et al., 1992). Behaviourism models are drawn from traditional classroom practices and have been used to design museum exhibits in the nineteenth and early twentieth century (Greenhill, 1999). This led to authoritative, didactic displays, frequently arranged to illustrate conventional epistemological hierarchies and classifications (Hein, 1998). Behaviour-based objectives are not always the most efficient approach to facilitate learning, especially in unstructured or informal learning environments. Along with the change in theories, an altered definition of learning itself has come into play. Learning is an active participation of the learner with the environment and museums become central to any educational effort (Hein, 1998).

ii. Experiential Learning Theory

The underpinnings of museum exhibitions, as we know them today, began with the Experiential Learning theories (Kolb, 1984) which has its' roots in John Dewey's philosophies related to the formation of knowledge. The increasing emphasis on exploration and reflection as well as with interaction and environments for learning can be attributed to Dewey's (1933) thinking and beliefs. John Dewey’s educational philosophy presented in 'Experience and Education' (1933) represents a seminal work in the foundations of experience-based education and museum education (Ansbacher, 1998). In this work, Dewey proposes a progressive philosophy that all knowledge is developed from within and that all genuine education is a result of experience. Fundamental to Dewey's educational philosophy is the idea that "…there is an intimate and necessary relation between the processes of actual experience and education" (1933, p.7). Dewey proposed two interrelated principles, continuity and interaction, to guide in identifying educationally worthwhile experiences. The principle of interaction is grounded in the notion that the conceptions of situation and interaction are inseparable. An experience is as it is because of the transaction taking place between “…an individual and what, at the time, constitutes his environment” (Dewey, 1933, p. 41). Dewey acknowledged the continuity of personal experience; that one experience builds upon the previous. He also recognized the relationship between a learner’s context and the way in which they learn. In a museum setting, this means that the museum environment influences a visitor’s learning. The implication is that visitor will take individual meaning from exhibitions based on their own previous experiences and their present experience in the museum.

Based on Kolb's experiential perspective, learning is an adaptive process through which knowledge and experience are continuously being recreated and transformed, both objectively and subjectively. Kolb states learning is "…the process whereby knowledge is created through the transformation of experience"(1984, p.38).

Kolb identify two major dimensions of learning: perception and processing (see Figure 2.1). Each axis has two poles: perception ranges from concrete experience to abstract conceptualization, and processing ranges from active experimentation to reflective observation. The two axes form a four-quadrant field for mapping individual learning styles. The intersection of the processing and perception dimensions creates a set of learning styles which emphasizes how people like to interact with learning content. Kolb's characterization of the modalities of engagement guide the exhibit developers in shaping an activity's structure to support these modalities.

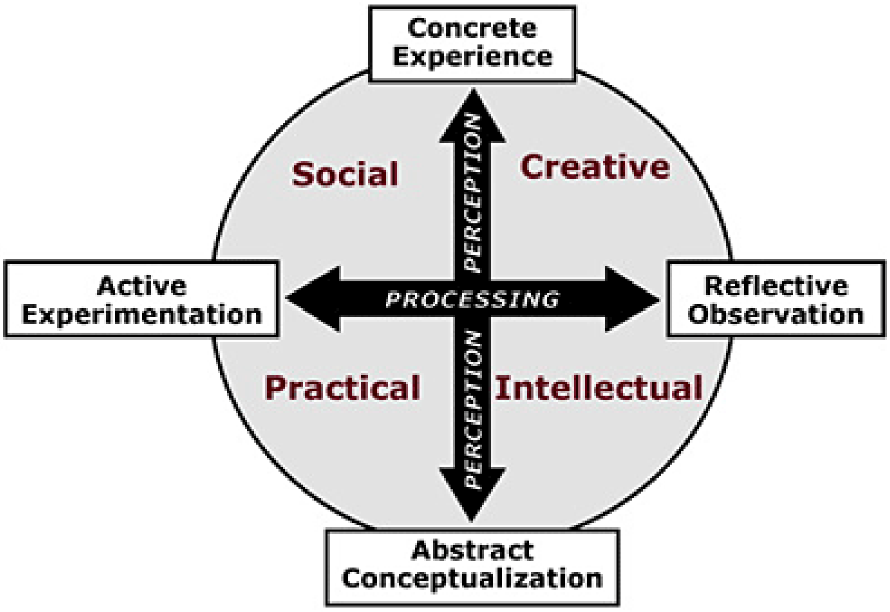


Figure 2.1: Experiential Learning Theory by Kolb et al. (1999)

iii. Multiple Intelligences Theory

Howard Gardner's Multiple Intelligences theory recognizes the different learning styles within visitors to museum exhibits. He posits that museums, when considering educational opportunities, should cater to people of various different intelligences, thus making exhibits widely accessible to all types of learners. The seven different intelligences include linguistic, logical-mathematical, musical, spatial, bodily-kinesthetic, interpersonal and intrapersonal (Davis & Gardner, 1999).

iv. Constructivism

Constructivism is an approach to the theory of education that is based on modern theories of learning - on the work of Dewey, Piaget and Vygotsky. It refers to the idea 'that learners construct knowledge for themselves - each learner individually (and socially) constructs meaning - as he or she learns' (Hein 1991: 89). The constructivist approach is applicable to both formal and informal education settings. Many museum experiences are designed to juxtapose museum goers' prior knowledge with the formal disciplinary ideas that can explain the natural phenomena they engage with in an exhibit or activity. This approach to design, focused on stimulating cognitive dissonance, is presumed to help learners question their own knowledge and more deeply reconstruct that knowledge. One example was developed by George Hein (1998). It allows for classification of museum-based and similar learning experiences along dimensions of the thinking they support or promote for participants. Hein's framework can be represented in a diagram depicting two orthogonal lines on a plane (see Figure 2.2). One plane represents the theory of knowledge (epistemology) embodied in an exhibit or museum. This ranges from realism (the world exists independently of human knowledge about it) to idealism (knowledge of the world exists only in minds and doesn't imply anything about the world "out there"). The second plane represents a theory of learning, which moves from a transmission model to a constructed model. This reflects a range from behaviourist commitments (e.g., knowledge is transmitted) to the variability in cognitive perspectives with respect to the extent to which knowledge is learner-constructed.

Hein's simple diagram can be used to classify the pedagogical approach of a museum or exhibit into one of four quadrants, on the basis of the kinds of learning environments they offer visitors. For example, quadrant 1 experiences are “didactic expository.” They assume scientific knowledge should be conveyed as factual and confirmed and that learners should be driven through this body of knowledge (rather than invited to think about and apply knowledge). In contrast, quadrant 2 is exemplified by experiences in a “discovery museum,” in which understanding emerges through self-directed interactions with the world and representations of the world. Quadrant 3, exemplified by the “constructivist museum,” portrays an environment in which individuals construct their knowledge of the world through integration of existing and new conceptions, making personal sense of what they learn. Quadrant 4, which Hein refers to as behaviourist, defines environments in which learners build knowledge of an external world by mastering “pieces” of knowledge incrementally.

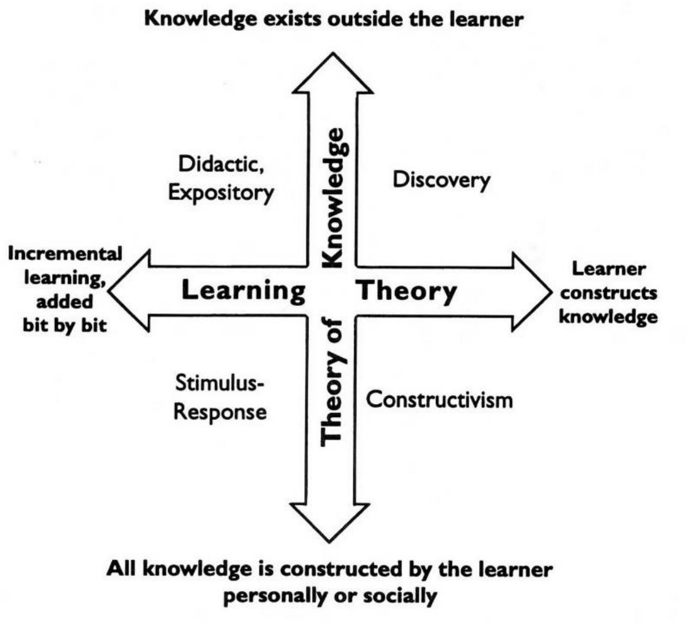


Figure 2.2: Educational Theories by Hein (1998)

Constructivist theory is focused on activity and builds upon some of the fundamental premises of Experiential Learning theory. Hein states (1999, p.76):

Proponents of constructivism argue that learners construct knowledge as they learn. They do not simply add new facts to what is known, but continually reorganize and create understanding and the ability to learn as they interact with the world.

Furthermore, visitors 'construct' their knowledge from the meaning in the exhibit. This leads to a different focus when considering exhibit planning. Constructivist educational theory argues that teaching and learning focus needs to be on the learner, not on the subject. Hein (1999) stress that the need is to focus on the visitor, not on the content of the museum. In conclusion, the environment can enhance learning through active participation of the user through meanings and messages of the exhibits. Meanings or messages from the exhibits which cater different intelligence contribute to the construction of knowledge. Table 2.1 summarises the learning theories in museum exhibition design which is applicable to science centres.

Table 2.1
Learning Theories in Museum Exhibition Design

	Theory of learning	Explanation	Theorist
1	Behaviourism	- Authoritative, didactic displays - Arranged to illustrate conventional epistemological hierarchies and classifications	Watson (1930) and Skinner (1948).
2	Experiential learning	- Experience and environment - Knowledge created thinking - Transformation of experience - Two dimensions: - Experience → conceptualization - Processing experience →reflective conceptualization	Dewey (1933) and Kolb (1984)
3	Multiple intelligence	- Different learning style for various intelligence - 7 intelligences - linguistic, logical-mathematical, musical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal	Davis & Gardner (1999)
4	Constructivism	- Knowledge constructed from meaning in the exhibits - The focus of teaching and learning on the subject (the visitor not the content of the museum)	Dewey (1933) Piaget (1936) and Vygotsky(1978) Hein (1999)

2.2.1 Educational Concept Applied in Museums

In this section, educational theories that have been applied in museum education programs and exhibitions are discussed. Concepts such as experience and education, child-centered learning, and learning through play have guided museum educators to consider how visitors learn. Museum educators have considered Vygotsky's (1978) theory, The Zone of Proximal Development - the distance between the actual developmental level and the level of potential development which may be facilitated under adult guidance. Engaging children and families' learning is designed by offering interactive exhibitions specifically for this audience.

i. Progressive Education

Dewey's critical thinking on curriculum and education made him the representative figure of the progressive education movement that started around 1915. Dewey's notion of "learning by doing" has had a tremendous impact on education (Cremin, 1959& Jackson, 1998). In addition, his pedagogical ideas have been applied to the field of museum education. Today, museum professionals, especially science centre and children museum often use terms such as 'hands-on learning,' as the educational concept integrated in their programs and exhibitions.

ii. Learning through play

'Learning through play' is also an educational concept that has an impact on how museum educators conceptualize their education practices. Scholars have used different terms and categories to define play, but they can be roughly grouped as below (Trageton, 2005):

1. Practical play - focus is on the development of interaction and sensor-motor development.
2. Dramatic play - engages the development of relational reasoning and imaginative creativity.
3. Constructional play - play facilitated the use of various materials, building play.
4. Rule play - play focus is on the development of operational and directional reasoning.

Franklin (1994) states that when children engage in pretend play, whether the content of play is related to making sense of everyday experiences or imagining beyond the everyday, they engage in an activity that enables them to understand themselves and the world they live in. Gardner (1983) argues that dramatic play has even greater implications: children's potential realization has a strong correlation with play. In particular, imaginative play can impact critical thinking, reasoning and social skills and competencies not just in childhood but through adulthood (Stephens, 2009). Current literature on play suggests that play has the value of making lessons more accessible and easier to be related to by students (Brown & Vaughan, 2010; and Landreth et al., 2009). Play is perceived by children as less restrictive. Thus, children tend to exercise greater freedom in expressing themselves and develop greater positive associations with the intellectual value associated with their activities (Sawa & Trimis, 2005). One of the implications is that they can develop a more positive perception about learning in general.

2.2.2 Discovery Learning in Museum

The design of museum exhibitions calls for a more adaptable, audience-focused, constructivist approach to providing quality learning experiences. Bruner’s ideas refer not only to cognitive development but also to knowledge in general. He looked at how cognition affects perception, and at language acquisition. He proposed three modes in which children represent the world: the enactive (where representation occurs through actions); the iconic (where representation involves building up a mental image of things [picturing] one has experienced); and the symbolic (where representation takes place through symbols) (Gross 1987; Vasta et al.,1992). Bruner's work on discovery learning has been very influential and widely used by museums, especially science museums which try to create open-ended experiences that encourage discovery learning (Hein, 1998). The following section discussed current practices in museum exhibition design and studies on visitors' learning in museums.

i. Constructivist Museum Design Elements

Museum education researcher, Hein (1998), embraced Dewey's writings on curriculum education and developed an educational theory of constructivist exhibition. He stressed the importance of applying constructivism to museum exhibition design. Constructivist theory argues that both knowledge and the manner in which it is learned are dependent on the minds of learners and require two components. First, learners should be encouraged to actively use both their bodies and their minds to experience the world: to manipulate, conjecture, experiment, and draw conclusions. Second, learners should be allowed to reach conclusions of their own without having to conform to an outside standard of truth. Therefore, constructivist exhibitions and educational experiences should allow learners to construct their own personal knowledge by incorporating certain design elements. Hein (1998) suggested these constructivist museum design elements.

1. Have multiple entry points

2. Provide activities with a range of learning modalities
3. Present multiple points of view
4. Enable visitors to make connections to their life experience

The prior knowledge and experience that learners bring with them to an educational situation is a key factor in learning. Educators also should create intellectual challenges that bring visitors beyond the known so as a result, learning occurs. Hein (1998) suggested two methods that museum professionals should consider to make exhibition content accessible to visitors:

1. Connecting the familiar to the unfamiliar
2. Exhibiting the known

In addition, Hein (1998) suggested that museum educators create opportunities for visitors to experiment in such a way that a range of results are possible and acceptable.

ii. Designing Interactive Environments for Learning

There are numerous factors which influence learning within a museum. Falk and Dierking (1992) states visitor learning as: "…integration of events and observations in mental categories of personal significance and character, determined by events in their lives before and after the museum visit" (1992). Learning in museums is related not only to what visitors experience in the museums but relies on past and future visitor experience. Falk and Dierking (2000) introduced a framework related to the gestalt of the museum experience. A model was devised attempting to "…accommodate much of the diversity and complexity surrounding learning"(2000). Their model, the Contextual Model of Learning (formerly called The Interactive Experience Model), emphasizes the interaction between personal, sociocultural and physical contexts involved in the museum visit. See Figure 2.3. Learning is the process/product of the interactions between these three contexts (Falk & Dierking, 2000). This theory of learning accounts for far more contexts than any of the previous methods and is specifically aimed at museum type of learning. Each of these three contexts is continuously constructed by the visitor and the interaction of these contexts results in a constructed reality and experience unique to the individual as shown in Table 2.2.

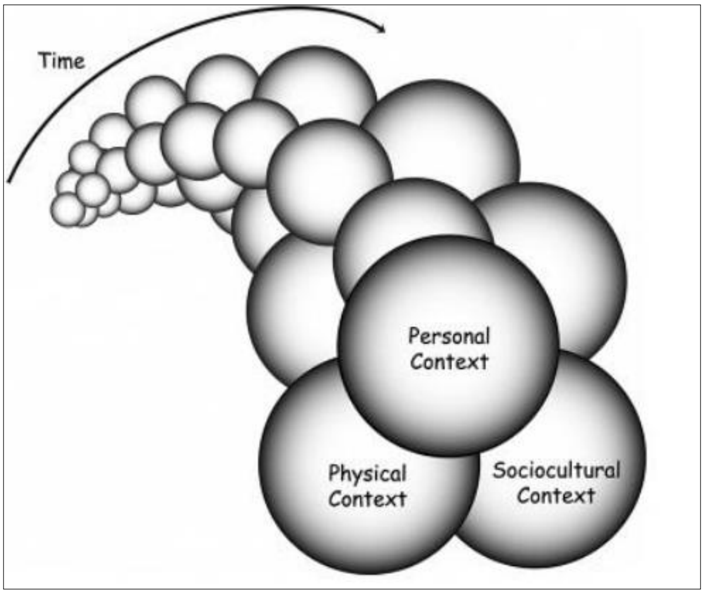


Figure 2.3: The Contextual Model of Learning by Falk and Dierking (2000)

Their model emphasizes visitor expectations and the importance of how a museum exhibit, the implications of the personal context and sociocultural context in the museum experience. The personal context that museum visitors bring with them includes the visitors' prior knowledge, interests, and beliefs. It also includes each visitor's personal choices. The socio-cultural context of a museum learning experience refers to within-group conversations as well as facilitated learning by others in the museum setting. Physical context means the orientation of the space and the design of exhibitions. Visitors' learning is influenced by the design - when exhibitions are appropriately designed, they become one of the best educational mediums and learning tools (Falk & Dierking, 2000).

Table 2.2
Key factors of the Contextual Model of Learning in museum

The Contextual Model of Learning		
Personal context	Sociocultural context	Physical context
• Motivation and expectations • Prior knowledge, interests, beliefs • Choice and control	• Within group sociocultural mediation • Facilitated mediation by others	• Design • Advance organizers and orientation • Reinforcing events and experiences outside the museum

When museums are able to provide visitors immersion experiences, which are well-designed exhibitions that envelop visitors in the sounds, smells, sights, textures, and even tastes of the objects or the theme of the exhibition, the experiences become very compelling (Falk & Dierking, 2000). Immersion experiences appear in different forms depending on the site, the collection, and the theme of the exhibition. In the designing process, museum professionals should conjure up different ways to contextualize the concepts that the exhibition intends to convey and design meaningful experiences for visitors (Falk & Dierking, 2000).

iii. Family Learning in Museums

According to Hein (1998), though learning remains an individual process, there is no denying the presence of external influences in that process. In the case of families, their impact is even greater because of the closeness of the relationships. Borun et al., (1996) states that families have a culture of shared knowledge and experiences. A family group that visits a museum can store knowledge for later sharing among family members.

Other authors credit the importance of family in museum learning to its significance in the construction of personal context (Xanthoudaki et al., 2003). The implication is that family learning is supported and enhanced by visiting the museum together and can increase the effectiveness of museum education efforts. Hein (1998) considers this another illustration of how museum experiences create a platform for the interaction of visitors' backgrounds and visitors' reactions to objects on display. Falk and Dierking (2000) documented a number of research studies regarding the interaction of families in several museums. The behaviour that has been most observed was that families exhibited freedom in conversation and interaction as they went about the exhibits. Observed participants in the studies all expressed that they felt that they could better interact with their family members by utilizing the museum interactivity. At the same time, they were better able to accommodate the information that they were learning because of the learning and social reinforcement they received through their family group. Thus, the family interactions are shown to be highly socially-oriented.

Hein (1998) points out that museums have to afford the option for families to independently pursue their own explorations and learning. Hein's suggestion is based on multiple intelligence theories and how individual pursuit and fulfilment of them can in turn enhance socialization and development of others such as parents with their children (Gardner, 1983). Therefore, the challenge for museums is to be able to encourage families to experience the museum as a family unit, relating it to their collective context, but also allowing them opportunities for individual enrichment.

iv. Children's Learning in Museums

Museum education has to encompass comprehensive, interdisciplinary, and collaborative strategies to be able to meet the expectations and demands of its various stakeholders. There are a number of central concerns that have to be considered, including issue-oriented contexts in museology; varying states of nature; status of nations; history, memory and other locations; arts, crafts and characteristics of visitors (Carbonell, 2004). This perspective underlines the importance of understanding the context of visitors which will affect their perceptions of the exhibit, how they will interact with it, and how they will communicate and relate it to other people and to other exhibits. Children's learning in museums is sometimes similar to classroom learning in terms of learning content, but requires a whole different set of pedagogies directly associated with the museum context. At the same time, there is also a need to recognize that though museums are considered as possible educational venues, the expectation of how learning is to be undertaken is not as determined or specific. This can be even more pronounced regarding children since their learning experience can be generally limited to classroom or informal home instruction. Thus, when a child comes into a museum, he or she may understand that it provides a learning opportunity but he is unlikely to have a clear idea of how this can be accomplished especially if the interactivity or the exhibit is not designed in a learning environment with which he is familiar (Paris & Hapgood, 2002).

Children's learning in museums builds knowledge by bridging exhibit themes, messages or designed learning with the child's existing schema. Educators must be able to effectively accommodate the social context of learning because these conditions are critical in determining and creating the capacity to learn as well as to interpret experiences and applications of learning (Muthusamy & White, 2005 and Olivera & Straus, 2004). In the case of children's learning in museums, the museums become the social settings for the children's learning experience, extending from the actual exhibitions or interactives in which they become involved (De Corte, 2003). Therefore, children's learning in museums is not just an educational but also a social and developmental process.

2.2.3 Learning Experiences and Meaning-Making

Learning occurs when they cannot explain these experiences using their usual way of thinking and are forced to make new meaning of the experience using prior knowledge and understanding (Merriam & Caffarella, 1999). Mezirow (1996) states that:

> Learning is understood as the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experiences in order to guide future action.

There are two components to the process: interaction and continuity. To make meaning, experience must be considered within the context of other experiences, i.e., the experience is influenced by prior experiences and will in turn affect perceptions and reaction to future experiences (Dewey 1938). Falk & Needham (2011) studied visitors to the California Science Center in Los Angeles during a decade after its opening in 1998. Results suggest that the science centre has had an important impact on the science literacy of greater Los Angeles. Self-report data by visitors indicate that the centre strongly influenced their understanding of science and technology. In an extensive international study on the impact of science centres, Falk et al., (2014) collected data from 17 centres in 13 countries, interviewing 13,558 persons. The results support the contention that individuals who used science centres were significantly more likely to be science and technology literate and engaged citizens. The more frequent, the longer and the more recent the science centre experience, the stronger the correlation for all outcomes. The study shows clear correlations between science centre visits and (i) science and technology knowledge and understanding (ii) interest and curiosity in science and technology (iii) engagement with science and technology related activities (iv) confidence in science and technology.

Science centre promote learning by providing an environment free of anxiety, fear and other negative mental states (Falk & Dierking, 2002). While visitors are on-site, their satisfaction with the experience is affected by a number of factors. In science centres or other free-choice setting, tired visitors who cannot locate rest areas are less likely to engage in learning opportunities than those who are comfortable within the same setting (Brochu, 2003). Disoriented visitors experience discomfort, anxiety and a loss of control, all of which hinder free-choice learning (Falk & Dierking, 2000). Uncomfortable noise levels, a sense of crowding and other factors that may make the visitor feel intimidated; also hinder learning (Knudson, Cable & Beck, 1995, and Rennie & Johnston, 2004). Once visitors' basic needs are satisfied, they are ready to connect to the site. Applying general safety and information needs to the museum setting, Rui Olds (1994) proposed four main characteristics of ideal museum environments:

i. Movement: The freedom to explore the environment in a self-directed manner.
ii. Comfort: A varied ambience and moderate stimulation of all the senses; variety in scale, finish, lighting, texture and mood.
iii. Competence: A sense of belonging and well-ordered and signposted spaces that allow visitors to find their way around with confidence.
iv. Control: To not feel exposed; the ability to protect ourselves from unexpected approach (a sense of safety in the environment).

Visitors that are comfortable and content are more likely to engage in activities that lead them to the central message in various forms (Falk & Dierking, 2000). Hence, they are also prone to internalize the affective and cognitive aspects of the message. Good visitor experiences encourage visitors to return and also influence. According to Perry (1992), requirements for an intrinsically motivating museum experience include the ability to instil curiosity, challenge, control, confidence, play and communication in the visitor's experience. Establishing interesting and motivating exhibits is a crucial aspect of a successful museum. In general, most visitors to museums are motivated by curiosity and an expectation of being able to satisfy that curiosity as a result of participating in the activity (Falk & Dierking, 2000). Keller's ARCS motivation theory (1983) could be useful in increasing visitor motivation by addressing the four motivational conditions: attention, relevance, confidence, and satisfaction (Gagne, Briggs, & Wager, 1992). Alessi and Trollip (2001) identify the following as ways to enhance intrinsic motivation: using game techniques; using visual embellishments; using exploratory environments; giving the learner control; challenging the learner; arousing the learner's curiosity and giving encouragement. Although these motivators are identified by Alessi and Trollip (2001) specifically for the implementation in multimedia, they are applicable to virtually any media or technology that might be used in a museum setting.

Science centres and other museums are designed to support learning experiences where visitors construct personal meaning about the world around them (Falk & Dierking, 2000). This meaning-making occurs through a constant process of remembering and connecting the present context to past experiences (Silverman, 1995). Visitors' understanding of central messages is enhanced when information gave new meanings and viewpoints about something they are already familiar with (Jacobson, 1999). Tilden (1977) reminds us that facts by themselves are sterile and to be effective, exhibits need to help visitors connect with what they are seeing or experiencing. Provoking visitors to build intellectual and emotional ties to the subject may result in a rich and powerful learning experience.

Within a more ‘interpretative paradigm’, design is recognised as an integral part of the visitor experience, with potentially more far-reaching implications for structuring the very nature of that experience (Macdonald, 2007). Modern science centres are designed to be rich in stimuli. The Exploratorium in San Francisco and the Ontario Science Centre in Toronto opened its doors in the late 1960s and count as the first exemplars of science centres. They allow people to be active rather than only to watch at showcases. They have shown alongside the static historical collection, machines in motion and allows visitors to turn on exhibits, e.g. models, by a button. Ranging from interactive exhibits and interpretive tours to interactions with personnel on-site, science centre communicate its messages with a view to influencing science knowledge, attitudes and behaviours of visitors (Falk & Storksdieck, 2005). A study by Salmi (2003) concluded that a series of visits to a science centre seemed to have positive effects on the motivation of all students. Students’ situational motivation can be changed to intrinsic motivation by well-organized programs linking schools to the open learning environments of science centres. The findings also suggest that both gifted students and students with learning difficulties were more motivated by the science centre visit.

Falk et.al (2004) 'Interactives and Visitor Learning' study focused on visitor perceptions of interactivity and the types of short and long-term learning that resulted from the use of interactives. The study showed that multiple types of learning outcomes occurred. The types of learning presented were (1) knowledge and skills; (2) motivation and interests; (3) perspective and awareness; and (4) social learning. Visitors enter the museum with pre-existing knowledge, experience and interest, and these pre-existing conditions strongly influence the in-museum learning. There is a significant difference in short-term and long-term learning outcomes: short-term outcomes relate predominantly to knowledge and skills, while long-term outcomes relate to perspective and awareness. This paper was the first to report such important outcomes of a science-centre visit. Prentice, Guerin, and McGugan (1998) hypothesize four processes on effective learning methods:

i. Attentional - does the sites attract and focus attention effectively?
ii. Affective - does the site allow visitors to enjoy themselves and create positive attitudes?
iii. Cognitive - do visitors absorb and retain information?
iv. Compensatory - does the site make adjustments for differently-abled learners?

They find that the causes of learning are complex. Simple models that predict how individuals learn may not be able to capture the whole picture. Random events have a greater influence than museum professionals and researchers might like. Falk (2004) reiterates that, for this reason, it is more likely that museums will strengthen what people already know, rather than changing their views outright.

Observation from a study using exhibit assessment tools by Barriault and Pearson (2010) shows three stages of visitor engagement: initiation, transition and breakthrough. A distinctive visitor engagement profile can be constructed for each exhibit and used in exhibit development. For exhibits studied at Science North, typically 20-80% of the visitors reached the transition stage and 20-60% reached the breakthrough stage. The breakthrough stage behavior can be considered empirical proof that learning has occurred in the exhibition. The paper also discusses the significance of the tool and how it can be applied to further enhance the learning experience.

Bitgood (2002) suggests that learning is part of the visit experience itself, and non-educational aspects of the experience can affect learning. Visitors must be well oriented to the physical and interpretive layout of the museum and be able to find their way from one space to another. Bitgood gives three principles of visitor interaction for 'setting factors' of the exhibitions/exhibits. First, visitor attention is discreet and selective, and distance and novelty affect whether visitors go to an exhibit. Second, there must be a high motivation to focus on the presentation once the visitor is there; if it is not interesting or there is something more interesting, they will wander off. Third, visitor attentions spans are affected by how much physical and mental effort they have to put in to stay on an exhibit. Given the varying opportunities available, every visitor's experience is unique. It is shaped by his/her motivations and needs. Refer Table 2.3 for key factors of museum exhibition design in relation to the four processes that affect learning experience: Attentional, affective, cognitive and compensatory (Prentice,et.al.1998). The relationship between the design characteristics of the exhibitions and the learning outcomes are cognitive and attitudinal.

Table 2.3
Key factors of museum exhibition design in relation to learning experience

Museum exhibition design in relation to learning experience		
Intrinsically motivating museum experience	Ways to enhance intrinsic motivation	Visitor interaction for 'setting factors'
Perry (1992)	Alessi & Trollip (2001)	Bitgood (2002)
• Curiosity • challenge • control • confidence • play • communication	• game techniques • visual embellishments • exploratory environments • giving control • challenging the learner • arousing curiosity • giving encouragement	• distance and novelty • high motivation to focus on the presentation • the level of physical and mental effort

2.3 PERSPECTIVES ON MESSAGE COMMUNICATION

Sociocultural theory emphasizes interpretation, meaning and explanation as processes and products of social interaction in museums. This theory presses on the issue of dialectics among curator, institution and viewer, and acknowledges that meaning is inherently social. Adults are constantly trying to interpret and index messages they receive to make sense of their everyday experiences (Tannenbaum, 1971). Message communication in museum activity embraces interpretation. Freeman Tilden (1957) defines interpretation as:

> An educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience, and by illustrative media, rather than simply to communicate factual information.

In an 'interpretative paradigm', design is recognised more fully as an integral part of the visitor experience, with potentially more far-reaching implications for structuring the very nature of that experience medium for presenting content (Macdonald, 2007). Belcher (1991) defined two main exhibition types: emotive and didactic. Emotive exhibitions were those produced for primarily aesthetic or evocative purposes such as the presentation of artistic objects, or theatrical and immersive exhibits. Didactic exhibitions on the other hand, were those with a more explicit educational intent and thus greater emphasis on interpretation (Belcher, 1991). Dernie (2006) categorises exhibitions as:

i. Narrative space: the juxtaposition of objects and displays in a way that sightlines and visitor movement reveal an unfolding narrative and layered storylines;

ii. Performative space: where the emphasis is on action rather than observation on the part of the visitor, for instance interactive exhibits;

iii. Simulated experience: immersive multimedia experiences and scenic reconstructions that could be considered an evolution and extension of the traditional museum diorama.

The twin concepts of mindfulness and mindlessness have been used in tourism research to explore visitors' responses to the interpretation offered at natural and cultural heritage attractions (Moscardo, 1996) and to support a mindfulness model of tourist experiences (Moscardo, 2009). A mindful tourist is actively engaged, aware of multiple or alternative perspectives, and alert to new information. A mindless tourist acts automatically and follows a routine script, without paying attention or actively processing information. Mindful tourists are more likely to have a satisfying experience, while mindless tourists are more likely to feel helpless, bored or frustrated (Moscardo, 2009). Mindfulness is normally seen as a necessary condition, or first step towards appreciation, meaning-making, attitude and behaviour change. A mindful visitor is active, interested, questioning, and capable of reassessing the way they view the world. This mindfulness can be created by interpretive practices that encourage control, interaction, and activity, as well as introducing novelty, pique the visitors' personal interests, and properly orient them to the interpretive subject. She notes that personal interpretation is very useful in facilitating mindfulness in visitors. Indications of mindfulness include increased visitor attention and attracting power, enhanced visitor preference for tours that induce mindfulness, greater interest in the subjects presented, and higher rates of factual learning and recall. Visitors should not just be passive absorbers of interpretation but must have some involvement. Environments need to promise a level of interest; a moderate stimulation of the senses (Rui Olds, 1994). For example, providing adequate signage and presenting exhibitions in a logical and thematically coherent way (i.e., scene setting) is a way of meeting visitors’ information needs (Goulding, 2000).

Educationalists have become aware of the increasing role of visual communication in learning materials of various kinds, asking themselves what forms of layout will be most effective for learning. The primary channels of communication at science centres are interactives and hands-on exhibits, signage, multimedia, science shows and science communicators. Interactive presentation attracts and holds visitors because the visitors have control over how much they will participate in the interpretation (Moscardo, 1999). It is important to understand not just what visitors learned, but how and why they learned from, enjoyed and appreciated particular exhibits or programs.

A 'language' is needed for speaking about the forms and meanings of these visual learning materials. Barthes (1977) regards visual images and music as text. Texts are reflections of cultural and ideological norms (O'Donohoe, 1997). Text has traditionally been perceived as the spoken word or written material that is in the realm of linguistics. Yet, the nature of text in contemporary culture has expanded. Fırat and Dholakia (1998) also emphasize that text has transcended being just the spoken and the written word. Texturizing the contemporary texts or in other words, endowing them with qualities that invoke senses, is a crucial strategy for communicating the ideas of these texts more effectively (Fırat & Dholakia, 1998). Through increasing application of textured text strategy, even in contexts like museums, one observes increasing use and role of multisensory interactive and virtual reality supplements to exhibits in order to create different learning and perceptual modes (Kotler, 1999). These supplements have started to play the key role in exhibits, as well as other textual contexts. The findings from these studies indicate the inter-relationship between exhibition environment design and effective learning.

2.4 VISITOR STUDIES IN THE MUSEUM

Visitor studies is consistent with transactional models of environmental psychology. The interplay between the person and the environment is essential for understanding the exhibition experience (Bitgood, 2002). This next section outlines the changes through a literature review on visitor studies. The focus is on the dynamic of exhibition-visitor, toward understanding the role of exhibition design in the visitor experience.

2.4.1 Museum Visitor Studies

Historically, a key premise of visitor research has been that the museum is primarily an educational or learning space; the original rationale for studying visitor behaviour was as an indicator of learning. The earliest systematic studies of visitor behaviour can be traced in the1920s and 1930s (Bitgood, 2011).In the late 1960s researchers began to address the question of how exhibits and their effectiveness might be evaluated. In one of these early studies, Shettel et.al (1968) proposed three categories of variables for studying the didactic effectiveness of exhibits:

i. Viewer variables - including prior knowledge, motivations and demographic profile design variables - primarily focused on the amount.
ii. Presentation of text - including sequencing and the inclusion of dynamic vs. static displays.
iii. Exhibit effectiveness variables - observable visitor behaviours and measurable changes in knowledge and/or attitudes.

The study identified the challenges of the museum setting in comparison to more formal educational settings. Visitor research has historically focused more on exhibition content than the nature of the environment in which it is situated. This is due to methodological challenges: it is difficult to isolate and study individual aspects of design without fundamentally altering the nature of the experience being studied. Consequently, visitor research in the museum space focused on the “minute and the measurable” (Leinhardt & Knutson, 2004) rather than broad questions about the role of exhibition design, particularly its more theatrical or affective aspects. In the 1980s and 1990s,developments in the perceived social and educative role of the museum had brought a greater impetus to the study of museum visitors (Hein, 1998), with models and research agendas for characterising the interplay between visitors, exhibits, and learning outcomes beginning to emerge(Falk & Dierking, 1992; Koran & Koran, 1986; and Screven, 1986).Theories of exhibition space and its role in the visitor experience have become a more significant research focus only in recent years (Peponis, Dalton, Wineman, & Dalton, 2004; Stenglin, 2004; Roppola, 2012; Schorch, 2013).

The most common form of museum visitor research, is survey work, usually carried out by museums themselves, possibly also using market research companies. It typically provides basic socio-demographic data on visiting, usually also coupled with information about which particular exhibitions or galleries are visited, repeat visits and satisfaction ratings. The other strand of museum visitor research might be called directed behavioural studies. These investigate specific aspects of visitor behaviour in exhibitions from a social psychological perspective. Examples of such studies have included looking at the length of time spent reading labels, time spent before ‘visitor fatigue’ sets in, spatial movements and social interaction such as amounts of time spent talking with other visitors (Falk & Dierking 2000).

It is a common practice in the cultural institutions to devote dedicated personnel to research on visitor satisfaction-related matters. In many cases, independent researchers and museum staffs are employed to talk to different visitors for feedback on exhibition theme and its learning facilities. For example, Leard (1992) assessed the relationship between motivations and satisfactions of visitors to the Edmonton Space and Science Centre (ESSC) in an attempt to understand more fully why individuals might return to participate in future leisure programs or activities. Visitors attending programs at the ESSC during the spring of 1991 served as the source of data. The data examine various demographic differences, gender and show selection, reasons for visiting and not visiting more often, differences in means for motivation and satisfaction and reasons for visiting and not visiting again in the future. The motivations identified with the highest means were education related. Motivations with the lowest reported means were related to skill. Satisfactions identified with the highest means were related to experiencing stimulation and educational opportunities. Satisfactions with the lowest reported means were related to social or skill development. The results and recommendations of the study provide insight on why visitors might or might not return to visit the ESSC again in the future and the intent they have shown to do so. The practical considerations of the study should assist in an attempt to enhance visitor retention within the leisure setting. While visitor satisfaction offers useful conceptualization for visitor perception and behaviour, it has yet to capture other important aspects of visitor experiences in the exhibition environment.

Visitors enter museums with pre-existing motives, affective dispositions and other personal characteristics that influence their response to interpretation and their satisfaction with the visit (Meredith, Fortner & Mullins, 1997). Research shows that family groups spend most of their time interacting and learning together, by verbally sharing what they know (Falk & Dierking, 2000). Conversations within all adult groups also focus on making sense of the exhibits. The presence of companions was thus found to influence learning and message reception in such settings (Falk & Dierking, 2000). Museum visiting is a social event but, study of visitor interaction in galleries is largely ignored by research. Heath and Lehn (2008) seeks to address this by employing video technologies to observe and analyse interactions among visitors in specific exhibitions. Their findings suggest that interactions with other people can be crucial to such matters as whether visitors even notice particular exhibits and they argue that:

> Interaction does not so much permeate a set of pre-established dispositions or bodies of knowledge, but rather provides the material and interactional circumstances through which people come to see and understand exhibits in particular ways.

Visitors come to museums with their own agendas and motivations, which in turn affect learning (Falk, Moussouri, & Coulson, 1998). These visit reasons are as diverse as education, entertainment, social events (Falk & Dierking, 2000), relaxation, enjoyment, spiritual fulfilment (Falk, 2005), vacations, family outing, visiting with someone else, brought others to see the museum (Prentice, Guerin & McGugan, 1998), restoration and social interaction (Packer & Ballantyne, 2002). Family togetherness, novelty seeking, and enjoyment were some of the motives mentioned by visitors. Thus, the primary motives were recreational and social rather than educational. Visitors do recognize the educational potential of science centres, but their motivation is more often focused on their children's education rather than their own (Morgan & Hodgkinson, 2000). Thus, in terms of social orientation, visitors were more likely to visit a science centre for altruistic reasons (to spend time with others, to educate a child), rather than for intrinsic reasons (e.g. educating themselves) (Morgan & Hodgkinson, 1999).

2.4.2 Visitor Experience

The meaning of visitors' experiences involves recreational activities (such as a museum visit) commence in a setting that has particular attributes; in order to experience certain consequences; and so derive desired benefits (Prentice, 1996). An empirical list of “satisfying experiences” was developed to classified these museum experiences into the following four categories (Pekarik, Doering & Karns, 1999):

i. Cognitive experiences focus on the interpretive or intellectual aspects of the experience and include gaining information or knowledge, or enriching understanding.

ii. Object experiences focus on something outside the visitor and include seeing "the real thing", seeing rare or valuable objects, and being moved by beauty.

iii. Introspective experiences focus on personal feelings and experiences, such as imagining, reflecting, reminiscing and connecting.

iv. Social experiences focus on interactions with friends, family, other visitors or museum staff.

Each visitor experience is unique. It is shaped by a few factors ranging from physical factors such as layout and orientation, to personal factors such as an individual's interests and identities (Falk, 2006). Some suggest the visitor experience is beyond the duration of the visit. The moment begins as one encountering information relating to a site, later makes a decision to visit, continues until the individual has completed the physical visit and it remain as a memory (Falk & Dierking, 1992 and Brochu, 2003).Visitor characteristics, such as prior knowledge, previous experience, interest, and group composition, in addition to motivation for the visit, can be clustered to create a motivational identity that can be used to understand visitor experience at museums

(Falk, Heimlich & Bronnenkant, 2008). Falk (2006) described five motivational identities:

i. Explorers – are primarily motivated by curiosity or a general interest in learning more about a subject.
ii. Facilitators – visit to satisfy the needs of others they cared about, especially their children, e.g., parents
iii. Professional/hobbyist – are similar to explorers, but already possess a strong knowledge of the subject. They were more interested in how the information was conveyed rather than the actual information, e.g., science teachers.
iv. Experience seekers – are often (but not always) tourists who seek the experience for the sake of being able to say they had done it.
v. Spiritual pilgrims – visited to be able to reflect, rejuvenate, and surround themselves with that environment.

Visitors may have multiple motivations visit (Heimlich, 2005). This identity is distinct to each visit and may not hold true for subsequent visits to the same site. Visitor uses a visit to build their existing identity while laying the basis for the next change in identity (Rounds, 2006). For each visit, these character groupings can be used to understand visitor behaviour at the site and how they process the experience once they leave the site (Falk, 2006). These identities could thus influence visitors' receptivity to museum messages during their visit.

Pekarik et al., 2014) have since identified that different visitors are predisposed to different kinds of experiences, and that these dispositions are capable of predicting visitor behaviour. Visitors' interests can be broadly classified as being one or two of the following:

i. Ideas - interest in concepts and facts;

ii. People - attraction to human stories and emotional connection;

iii. Objects - attraction to objects and aesthetics;

iv. Physical -a propensity towards multisensory engagement and interactivity.

They are known collectively as IPOP (Pekarik et al., 2014). When related to observed visitor behaviour by combining surveys and visitor tracking, IPOP categories have been shown to have predictive and explanatory power in terms of which exhibits visitors stop at as well as those that they avoid.

Findings from observational studies have led researchers to theorise strategies that visitors deploy when navigating exhibitions. Rounds (2004) characterises the museum space as an "interest landscape", in which visitors engage in exploration behaviours to seek out experiences that meet their curiosity-driven needs. Visitors seeking out learning experiences by spanning through several exhibitions briefly can be a more effective visit strategy than viewing a single exhibition thoroughly; thus he argued that it is inappropriate to consider visitors' use of around 20-40% of exhibition elements as a "failure" – on the part of either the exhibition or the visitor. Rather, such a finding challenges museums to re-evaluate the museum-visitor relationship, and broaden the definition of learning in the museum: future research should "expand the inquiry to areas inclusive of a broader affective and social spectrum of museum visitor behaviours, not limited to the traditional measure of cognitive outcomes" (Spock, 2006, p. 170).

The following discussion gives another overview on the relationships between visitor emotions and other variables in museum settings. This well-accepted norm is gradually giving way to emotion-oriented concepts as the cultural institution is undergoing a major shift towards experience-based offerings for differentiation. Interconnecting is concerned more broadly with 'ways of relating', which nicely incorporates attention to ways in which visitors ‘assemble’ impressions and ideas, and considering how these interconnect with the exhibition design and other aspects of their lives. Ruth Finnegan’s argue for a broad approach to communication that is not restricted to the cognitive or linguistic but also includes the embodied and emotional (Finnegan 2002). This characterisation also suggest that the experience of an exhibition is not necessarily temporally confined to the time that a visitor is actually in an exhibition but extends beyond this, especially into its relating afterwards (Falk et al., 2006). Packer and Ballantyne (2002) highlighted the importance of design in achieving emotional impact beyond learning. A large percentage of visitors are there to kill time, to be entertained, and to satisfy their curiosity. Visitors allow themselves to be drawn into learning experiences, following curiosity and learning for learning’s sake. Packer (2006) described this enjoyable museum visits as “Learning for Fun”. A sense of discovery or fascination; appeal to multiple senses; appearance of effortlessness; and the availability of choice were some of the factors that support Learning for Fun experiences (Packer, 2006). Staging memorable experiences for museum visitors should lead visitors to future museum participation and increased learning, appreciation and enjoyment. Falk & Dierking (2013) note that “museum experiences, both exhibitions and programs, are remarkably memorable. The vast majority of visitors to museums create durable memories of some aspect of their experience. The persistence of museum memories is one indicator that museum experiences promote learning.”

Next discussion gives another perspective on visitor experience that revealed visitors are socially constructed as learning subjects. Exhibitions can be considered as the construction of meaning in three-dimensional space; space has a language and grammar that can be analysed and theorised using concepts that have originated in linguistics and semiotics (Anyfandi, Kouladis, & Dimopoulos, 2010; Austin, 2012; Stenglin, 2004, 2009). Semiotics is the study of signs and symbols, especially the relations between written or spoken signs and their referents in the physical world or the world of ideas. Semantics is the study of the relationships between signs and symbols and what they represent. Koulaidis, Dimopoulos and Matiatos (2002) considers science centres as 'texts' that employ a variety of semiotic modes for constructing their own messages. Roppola (2012) developed a theory of visitor experience based on multimodality, a broader semiotic concept that encompasses all the ways a culture might express meaning. Multimodality is the integration of multiple modes in the creation of meaning. Text, speech, images, gestures and sounds are all examples of semiotic modes. Fonts and colours can be considered modes in some contexts. The main functions of these messages refer to the degree of the techno-scientific content specialization, the degree of specialization of the corresponding expressive codes as well as the interpersonal/affective relationships that tend to be established with their potential visitors. These three functions become operational by applying a specific socio-semiotical analysis of the expressive modes including written language, text formatting/layout, two and three-dimensional representations, sound, lighting and degree of linearity.

Framing is used to describe the overarching structures visitors apply to the museum in order to make sense of their experience (Roppola, 2012). In general, frames are a collection of categories, criteria and expectations people use as part of the meaning-making process in daily life. People's museum and exhibit frames are informed by their past experiences, and inform their expectations regarding what a museum should be like and what sorts of experiences they can expect to have there. The analysis of a representative part of a typical science centre along the dimensions of classification, formality and framing revealed the way the visitors are socially constructed as learning subjects. It uncovers the underlying epistemological and sociological principles that determine the construction of their techno-scientific messages. These systems cooperate so as to create a coherent discursive ensemble that tends to shape both the epistemological and the pedagogical message of a science centre. These messages are either explicitly or implicitly communicated to a visitor through a process called synesthaisia, meaning that all his/her senses take part in their reception (Kress and van Leeuwen, 2001). Such a grid is important for a science centre since the style of the exhibit presentation deeply affects the kinds of thinking engaged in by visitors (McManus,1989). The corresponding image of the science learner that emerges is a person who need to grasp few at a time essentials of the techno-scientific content in order to be able to explain its natural and technological environment, without though needing to be tangled up with the complexities of the specialized and abstract techno-scientific conventional expressive systems but definitely needing to develop an investigative and independent approach towards science learning.

A limited number of studies were conducted on how parameters of an environment affect visitors' perception of space. Space syntax is a way of describing, quantifying and analysing spatial relationships that has been used in architecture and urban design, including museum buildings (Hillier & Tzortzi, 2011). Space syntax quantifies spaces in terms of their juxtapositional relationships, taking the rationale that this is a better predictor of how visitors use and make sense of space than simple size or distance (Hillier & Tzortzi, 2011). Two key syntactic measures of space are "integration"(the more integrated the configuration, the fewer spaces must be traversed in order to reach all other areas), and "connectivity"(the number of other spaces directly accessible from a given space) (Hillier & Tzortzi, 2011). However, when considering the visitor-exhibition dynamic, space syntax puts primacy on the spatial parameters of an environment rather than how visitors' individual characteristics may shape perception of that space.

The design appearance of the exhibition environment has been studied only rarely, and those experiments that have been conducted are of limited scope. During the formative evaluation of a cave exhibit, Bitgood et al (1987) compared lighting levels in a simulated cave environment. They found that medium levels of lighting were more appealing and dramatic than lower or higher. However, all three of the experimental lighting levels were low in the context of normal ambient interior lighting, plus a cave environment is one that is expected to be dark. Similarly, low lighting was hypothesised to be a factor in the high sense of immersion found in a narrow and low-lit minerals hall, evocative of a mine environment (Harvey et al.,1998). The general applicability of these findings is not clear, beyond acknowledging that light levels can affect the perception of a space.

In another study, Stenglin (2004) developed a theory of the experience of museum spaces based on the concept of "binding", drawn from linguistic theory. Binding theory is based on the premise that a key factor in our affective responses to space is a sense of security. Binding is thus a measure of how a space closes in or opens up around a visitor. Bound and unbound spaces are associated with positive affect: comfort, security, freedom, happiness and satisfaction (Stenglin, 2004). Criteria for bound and unbound spaces are culturally shaped, with different cultural and socioeconomic norms affecting what kinds of spaces will feel optimally bound or unbound (Stenglin, 2004). Applying binding theory to the design of exhibitions, Stenglin (2004) argued for incremental rather than sudden or dramatic changes in binding state from one space to the next, which can be disconcerting and distracting. However, she also maintained that some variation in binding state over the course of a museum experience is desirable, hypothesising that such variety can be stimulating and thus prevent museum fatigue. While Stenglin draws upon numerous examples in museum exhibitions and buildings, many of the hypothesised outcomes are theoretical as she did not directly study the impact of binding state on the visitor experience. This remains an area open to future research.

The exhibition environment is far more complex and multifaceted than a text. Roppola (2012) developed a theory of visitor experience based on multimodality, a broader semiotic concept that encompasses all the ways a culture might express meaning. The interconnecting concepts of framing, resonating, channelling and broadening can be seen taking place simultaneously over the course of a museum visit. The concept of resonance is used to characterise the interaction between visitors and features of the exhibition environment. Certain environmental features, such as "size, beauty, colour, light, a quality of realism, sensory change/movement and opportunity for action" tend to attract visitors and draw them in. Spaces can also have resonant qualities: environments that feel pleasant to be in owing to characteristics such as light, spaciousness or aesthetic appeal. "Broadening" is the term used to describe visitors' engagement with the interpretive content of museums, as they negotiate "the poetics and politics of display" (Roppola, 2012, p. 217). Examples of broadening that take place in museums include:

i. Experiential broadening: seeing or doing something you would not normally have the chance to.
ii. Conceptual broadening: improving understanding of a theoretical principle.
iii. Affective broadening: exploration on an emotional level.
iv. Discursive broadening: considering an issue from another point of view.

This study suggests that understanding the museum visitor experience could benefit from further research that looks at broader patterns in the museum visitor relationship rather than being limited to the specifics of exhibit content.

The next discussion gives another perspective on the logic underlying the structuring of visitor experience offered by a cultural institution at Valencia’s City of Arts and Sciences (Mencarelli & Pulh, 2012). The structuring and symbolic elements were analyzed based on visual ethnology by working on the photographic medium (Heisley, 2001; Collier, 2003; and El Guindi, 2004). From an ethnographic perspective leading to a solid anchoring in a natural context, photography provides detailed and direct information from the field. This research, as an extension of other studies (Belk & Kozinets, 2005), illustrates the various advantages of employing the photographic medium as a tool in research. In methodological terms, the interpretative approach deployed around photographic material offers perspectives for understanding and analyzing the structure of symbolic and experiential offers. For each dimension of the visit experience, the researcher looks at its content and the resources employed by its designers. The analysis reveals four main symbolic dimensions structuring these hybrid cultural offers. The research implications update a hybrid form of cultural experience that goes beyond the classic combination identified in the analysis of edutainment strategies.

2.5 EXPERIENCE DESIGN

Experience design is an approach to design that is growing in importance. It is still in its infancy as theoretical principles are taking shape. Also, there is much room for development in terms of methods, tools and professional practices. This recent design approach originates from the user-centric paradigm of design. Defined in the broadest sense, experience design is a field concerned with the design of anything people experience (User Experience Network, 2006); and it is an approach to creating optimal experiences for people in any medium (Shedroff, 2006). While experience-oriented design disciplines are dominant and increasing, the underlying user-centric beliefs are applicable to all types of products, environments, service and systems. Hence, some design scholars and practitioners advocate the broader sense of experience design by stressing it as a holistic approach to design that focuses on the in-depth understanding of users and the synthesis of multi-disciplinary knowledge for optimal design outcomes. It pointed out that rather than defining experience design within the narrow context of design disciplines (such as interaction design or HCI), experience design should be considered as a holistic and multidisciplinary design approach. Experience design should emphasize an in-depth understanding of users and the synthesis of wisdom from different disciplines. This can be transformed into design outcomes that help users achieve great experiences (Diller, Shedroff & Rhea, 2006). Hence, experience design can be interpreted as a design approach that is applicable to various design domains. The premise of this approach, as Suri (2004) put it, is:

> A maturing confidence in the human-centered design profession that challenges the wisdom of focusing on the individual artefacts themselves when people's interactions can be better supported by thinking about design opportunities more holistically.

Based on this fundamental experience-centric belief, designers synthesize various elements for the sake of staging pleasant user experiences. This focus has prompted researchers and practitioners to study elements that contribute to good experience and ways to implement them through a holistic, multidisciplinary approach. Nathan Shedroff (2001) one of the most active advocates of experience design assert that experiences consist of four stages: attraction, engagement, conclusion and extension.

According to him, elements that contribute to superior experiences are knowable and reproducible, which make them designable (Shedroff, 2001). He stated:

> What these solutions require mainly is an understanding by their developers of what makes a good experience; then to translate these principles... into the desired media without the technology dictating the form of the experience.

Shedroff suggested concepts such as immersion, metaphors, authenticity, interactivity, sensory exploration, and adaptivity which designers can explore when designing for great experiences. He emphasized the need to explore new research methods that understand people beyond issues of usability, such as methods that address human needs from emotional and social perspectives. Diller, Shedroff and Rhea (2006) highlighted the importance of meanings as the focus of experience design. Margolin (1997) emphasized the importance for designers to know how, for whom and purpose of their design. The continuing proliferation of experience design has provided grounds for design researchers to experiment with various methods for the sake of obtaining useful and in-depth understandings about users and their experiences.

According to Wright et al. (2003), people engage in experiences by actively structuring them through six processes of sense making. These reflexive and recursive processes are: (1) Anticipating; (2) Connecting; (3) Interpreting; (4) Reflecting; (5) Appropriating; and (6) Recounting. Therefore, the task of designers is to design for experience through a sensitive and competent way of understanding the users. Brochu's (2003) Visitor Experience Model divides the entire experience into five phases: decision, entry, connection, exit and commitment phase. In the decision stage, visitors are influenced by the site's promotional messages; past experiences, as well as what others, may have told them about the site. Once visitors approach the site with the intention of visiting, they begin the entry phase. At this phase, their satisfaction is based on their initial perceptions of the site including ease of locating the site, as well as quality of interactions with ticketing and front desk staff. The most commonly recognized phase of the visitor experience is the connection phase. Visitors move through the site, visit exhibits, attend presentations and engage in a variety of different learning activities. The exit phase begins once visitors decide to leave the site. During this phase, visitors decompress their experiences as they head to the parking lot. Finally, in the commitment phase, visitors use the messages to shape their beliefs, attitudes and behaviours. This period extends from soon after the return from the trip to the point where the memory of the visit begins to fade (Brochu, 2003).

Research interest is expanding to the broader context of people’s experiences. Studies on design for emotions also increasingly touch upon related systems, environments and service. These elements are becoming more intertwined and they are seldom experienced independently from each other nowadays (Suri, 2002). In light of this, more recent research studies address design for emotions in relation to experiential concepts. Blythe and Hassenzahl (2003) analyzed enjoyable experiences and stated that enjoyment is context-dependent and relational. Drawing on psychologist Csikszentmihalyi’s (1990) concept of 'flow' which refers to the euphoric sense of engagement when the division between a person and his or her task disappears, Blythe and Hassenzahl (2003) differentiated 'fun' and 'pleasure' as two distinct but equally key concepts in enjoyable experiences. According to them, fun is distraction that enables people to become temporarily oblivious of their problems and self-definition. The distraction with short-livedness and superficiality fulfil an underlying psychological need. In comparison, pleasure is a deeper form of absorption that happens when people are keen to an object or activity; when they try to make sense of themselves, explore and develop their identities. Their analysis adds to the range of knowledge regarding design for experiences.

The rapid increase in research effort directed towards affective qualities of human-product interaction has resulted in a wide array of experiential concepts. The experiential concepts discussed earlier are only some prominent examples. Demir, Desmet and Hekkert (2009) classified experiential concepts in design research literature within a framework of three levels of product experience. The three distinctive levels are: aesthetic pleasure, attribution of meaning, and emotional response. The omission of functional performance is indicative of the shift of research focus away from usability when it is considered a must in product features now. Under the three main levels, experiential concepts are further classified into nine categories, namely aesthetics of interaction, attachment, attraction, engagement, enjoyment, luxury experience, playfulness, resonance, and "wow". Their attempt at classifying experiential concepts is illuminating as it has shed light on research foci in relation to emotion-oriented experience design as well as drawn attention to the need for establishing common frameworks for discussion.

The scope of emotion-oriented design is gradually broadening the contexts of experience. More design projects aim at addressing experiential concepts. For example, an edited volume of design research and case studies that addresses the experience of fun regarding interactions with products was published with the title 'Funology' (Blythe et al., 2003). The affective experience called "wow" is defined as the combination of three emotions: pleasant surprise, fascination and desire. According to Desmet, Porcelijn and van Dijk (2007) to design for "wow" means the design team should design a product that is appraised, unexpected, unfamiliar, promising and fit for possession. Table 2.4 summarises the experiential concept which is applicable to science centres.

Table 2.4
Experiential Concept

	Experiential Concept	Author
1	Designers can explore concepts such as immersion, metaphors, authenticity, interactivity, sensory exploration, and adaptivity when designing for great experiences.	Shedroff (2001)
2	People engage in experiences by actively structuring them through six processes of sense making. These reflexive and recursive processes are: anticipating, connecting, interpreting, reflecting, appropriating and recounting.	Wright et al. (2003)
3	Visitor Experience Model divides the entire experience into five phases: decision, entry, connection, exit and commitment phase.	Brochu (2003)
4	Three levels of product experience are: aesthetic pleasure, attribution of meaning, and emotional response. Experiential concepts are further classified into nine categories, aesthetics of interaction, attachment, attraction, engagement, enjoyment, luxury experience, playfulness, resonance and "wow".	Demir, Desmet and Hekkert (2009)
5	The affective experience called "wow" is defined as the combination of three emotions: pleasant surprise, fascination and desire.	(Blyte et al., 2003).
6	Design for "wow" means the design is appraised, unexpected, unfamiliar, promising and fit for possession.	Desmet, Porcelijn and van Dijk (2007)

Apart from experiential products, more projects also aim at designing for experiences that generate intended emotional effect in the environments and service. For example, a noteworthy and successful case is the Ambient Experience Suite project by Philips (Figure 2.4) for improving child patients' medical scan experiences in hospitals both emotionally and physically (Philips, 2014).

Figure 2.4: Ambient Experience Suite project by Philips

In early 2000, Philips Design started to explore another route to reduce patient anxiety. By redesigning the total experience of a patient undergoing CT treatment, not only the patient's wellbeing but also the efficiency of the workflow and the clinical outcome could be improved. Philips uses the term Ambient Experience to describe the use of coloured light, projected images and sound. This line of research could be traced back to psychological research on experiences of person-object attachment as demonstrated by the classic research by Csikszentmihalyi and Rochberg-Halton (1981).

2.6 ATMOSPHERICS IN THE MUSEUM CONTEXT

Atmospherics, a term used for the overall design and ambience of leisure settings is an important factor of experience quality (Chang & Horng, 2010 and Lin, 2004). Atmospherics was originally defined as the conscious designing of space to create certain effects in buyers (Kotler, 1974). Its central premise is that the environment has the capacity to influence people's behaviour via sensory and emotional mechanisms, and that this influence can be manipulated in observable ways through design choices. According to Kotler's original definition, a store's "atmosphere" comprises its sensory elements which together communicate with shoppers through attention (standing out from the crowd), message (regarding the type of establishment and store image) and affect (colours, textures and sensory cues that subtly influence consumers). He predicted atmospherics' significance to be utmost in instances of pleasure-based (hedonic) consumption (Kotler, 1974). Studies in atmospheric support the notion that changes in the environment can lead to apparent changes in both attitudes and behaviour (Ng, 2003, and Turley & Milliman, 2000). As a complement to Kotler's model for atmospherics, Baker developed a typology of the service environment that characterised atmospheric cues as either ambient (temperatures, sounds, odours), design (layout, colour, interior design), or social (presence of other customers and store employees) (Baker, 1987). It is the design elements of the exhibition atmosphere that are of interest to this study.

Atmospherics offers a possible organizing framework for the study of visitors' affective, cognitive, and behavioural responses to the physical cues of the exhibition environment. Design decisions such as positioning of directional signage, the presence of contextual "scene setters", and the location of choice points have been shown to affect visitor orientation and the number of exhibits that visitors will encounter and attend to (Klein, 1993; Goulding, 2000; and Bitgood, 2011). Light and colour will be significant elements in the determination of overall perceptions of an exhibition environment, the general 'feel' of spaces and the subsequent visitor experience. This significance has been acknowledged by other researchers (Kottasz, 2006; Roppola, 2012; & Stenglin, 2004).

The importance of atmospherics is also supported by additional qualitative evidence. In a series of semi-structured interviews with museum visitors exploring perspectives on the value of the visit, comments regarding the general atmosphere or ambience emerged in 43 percent of interviews (Packer, 2008). In another exploratory study using open-ended interviews with museum visitors, atmospheric factors were a recurring theme in the way people described their visit and what attracted their attention (Roppola, 2012). Furthermore, a longitudinal qualitative study demonstrated that exhibition layout and spaciousness were capable of evoking a "spatial feeling" among visitors, which remained as a lasting impression of the museum experience (Schorch, 2013). These findings support the assertion that the atmospheric dimension of a museum experience is important to a significant proportion of visitors.

As in the consumer environment, the perceived atmosphere constitutes an important part of the exhibition experience, as this quotation from a recent exhibition review indicates: "…the gallery has been beautifully designed and lit, creating a soothing blue subaqueous environment in which visitors' swim in and out of pools of light like languid fish. Above their heads, the atmosphere twinkles and flows" (McAdam, 2011, p. 42). Conversely, an exhibition perceived to lack these elements may be disappointing: "I expected to see the colour of blood, the brightness of fire, the vast azure expanse of the sea, but I mostly saw the same dull grey" (Handley, 2014, p. 47). These examples illustrate how atmospherics can be considered as a form of interpretation and an additional communication medium within the exhibition space; an evocation of Kotler's "silent language" (Kotler, 1974).

In the museum context, exhibitions have been likened to a play: an exhibition has an overarching theme or storyline (plot) that can be divided into acts (galleries or subdivided spaces) and scenes (display clusters). Individual elements such as text panels, images and objects can in turn be related to dialogues, soliloquies and props (Crawley, 2012; Rabinowitz, 2013). Similarly, Yellis (2010) draws parallels between the museum and the theatre in the sense that both have the capacity to transform visitors on an emotional level. He argues that both a strong narrative as well as attention to the exhibition staging, or atmospherics, are important for enacting this transformation. These parallels between theatrical design and exhibition creation are embodied in the term scenography, an approach to spatial communication in which form, content and media are inseparable components of an experiential whole (Bofinger, 2010).

Doering (1999) noted that a museum that is liable to visitors for certain kinds of experiences will remove barriers that hinder. Museum will afford settings that support and enhance those experiences, and she exemplify aspects of the museum environment that impact on visitors' experiences based on Bitner's (1992) concept of 'servicescape'. The service environment includes ambient surroundings such as temperature, lighting and noise; spatial layout and functionality; signs and symbols; and the quality of furnishings which suggest expectations and 'image'. The servicescape that explicitly and implicitly convey expectations and 'image' influence customers' (or visitors') emotional, cognitive, and physiological responses to the environment. The original servicescape has been extended and modified to create models such as the designscape and the experiencescape (Chui et al., 2010; Rosenbaum & Massiah, 2011).

There are numerous studies in the literature about visitor experiences and museums. For example, in a study based on open-ended interviews with over 200 visitors to a variety of museums, the concept of framing, resonating, channelling and broadening can be seen taking place simultaneously over the course of a museum visit (Roppola, 2012). Framing is used to describe the overarching structures visitors apply to the museum in order to make sense of their experience (Roppola, 2012). In general, frames are a collection of categories, criteria and expectations people use as part of the meaning-making process in daily life. People's museum and exhibit frames are informed by their past experiences, and inform their expectations regarding what a museum should be like and what sorts of experiences they can expect to have there.

Visitors seek a 'total experience', where leisure, culture, education and social interaction can be included (Rojas & Camarrero, 2006). The service sector may create experiences in two ways: They may be experiential by nature or they may develop additional experiences for their core service. As museums are seemly more conscious of understanding how decisions impact individual visitor experiences, they are also becoming more conscious of providing a more pluralistic and holistic museum learning environment for all visitors. Museums are designing exhibitions to draw a general public audience, and exhibit professionals are expanding their variety of exhibit themes and experimenting with new display techniques and styles of development (McLean, 1993, 2004). In recent years, as edutainment and leisure competition becomes keener, museum management explore new approaches to achieve differentiation. Researchers also seek alternative frontiers for new insights. Both research and practice are undergoing fundamental changes that direct increasing attention towards visitor experience planning. This encompass the big picture: assisting visitors with orientation and wayfinding, ensuring they feel welcome and at ease, providing the appropriate amenities and comforts, supporting their desire to learn, and contributing to their overall enjoyment and fun.

Another study by Forrest (2013) adds to the increasing body of evidence that atmospheric features of the exhibition environment are important for visitors' navigation, sense-making and affective engagement. Using the Perceived Atmosphere Instrument, four dimensions of Perceived Atmosphere were identified: Vibrancy, Spatiality, Order and Theatricality. These four factors were able to meaningfully characterise how visitors perceive different exhibition environments and provide a deeper insight into how different exhibition settings are viewed from the visitor perspective. The instrument provides exhibition designers and visitor researchers with a new approach for characterising exhibition environments in a way that can inform future exhibition development. It comprises measurable constructs that contribute to a shared language among exhibition designers, educators and evaluators. Linking Perceived Atmosphere to broader psychological theory increases understanding of how and why visitors perceive and respond to different kinds of exhibition spaces in certain ways. These findings help inform future exhibition design and creation of museum exhibition environments to encourage intended visitor outcomes. Table 2.5 summarises atmospherics in the museum context which is applicable to science centres.

Table 2.5
Atmospherics in the Museum Context

1	Atmospheric variables include layout, crowding, product (exhibit) location, music, colour, lighting, and aroma.	Kotler (1974)
2	A typology of the service environment that characterised atmospheric cues are ambient (temperatures, sounds, odours), design (layout, colour, interior design), and social (presence of other customers and store employees)	Baker(1987)
6	'Servicescape' includes ambient surroundings, temperature, lighting and noise; spatial layout and functionality; signs and symbols which suggest expectations and 'image'.	Bitner (1992)
3	Positioning of directional signage, the presence of contextual "scene setters", and the location of choice points affect visitor orientation and the number of encounter by visitor.	Klein (1993) Goulding (2000) Bitgood (2011)
4	Light and colour are significant elements in the overall perceptions of an exhibition environment, the general ‘feel’ of spaces and the subsequent visitor experience.	Kottasz (2006) Roppola (2012) Stenglin(2004)
5	The concept of framing, resonating, channelling and broadening can be seen taking place simultaneously over the course of a museum visit.	Roppola (2012)
7	The ability to characterise exhibition environments is by the Perceived Atmosphere properties of vibrancy, spatiality, order, and theatricality.	Forrest (2013)

2.7 EXPERIENCE DESIGN IN SCIENCE CENTRE

Science centre offer visitors exciting opportunities to discover scientific ideas and ways of thinking through fun, interaction and hands-on science exhibits. Most science centre professionals agree that these attractions nurture curiosity, improve motivation and attitudes toward science, engage the visitors through participation and social interaction and create excitement and enthusiasm, all of which are contributing to science learning and understanding (Anderson & Cook Roe, 1993, and Dierking & Falk,1994). Science centre now have diverse aspects of role, from a focus on exhibiting and educating the public, to comprehend and assemble visitors' multiple needs. The learning-oriented entertainment experience (Falk & Dierking, 1992) of science centre seek to enhance the visitor experience through an experiential redefinition of the museum offer. Dernie (2006) highlighted exhibitions as integrated experiences. Experience design builds a context out of the display object or product with the aim of engaging the visitor at an emotive level and attaching a personal memory to the experience of the visit. The character of the physical setting is essential to the creation of a memory-rich experience.

Thematization is defined as the patterning of space, activity or event to symbolize experiences and/or senses from a special or a specific past, present, or future place, activity or event as currently imagined (Fırat & Ulusoy, 2009). These culture based strategy is so influential in contemporary society that, consumers have more powerful and significant experiences in "themed environments" than in other environments (Sherry et al. 2007). Besides thematizing the experience, enchantment can be trigger through spatialization. It is the physical environment in which the visitor experience occurs, through definition of the architecture, decoration and the general atmosphere of the place. Considerable resources are expended in the design of exhibitions, with a growing emphasis on the creation of environments with immersive, themed, and theatrical elements (Bofinger, 2010). In the science centre context, some exhibitions have also been likened to a play: an exhibition has an overarching theme or storyline (plot) that can be divided into acts (galleries or subdivided spaces) and scenes (display clusters). Yellis (2010) argues that strong narrative and attention to the exhibition staging, or atmospherics, have the capacity to transform visitors on an emotional level. The parallels between theatrical design and exhibition creation are embodied in the term "scenography", an approach to spatial communication in which form, content and media are inseparable components of an experiential whole (Bofinger, 2010).

The word scenography has emerged relatively recently in theatrical design (Howard, 2010). As a discipline, it transcends set design to encompass “the totality of visual creation in the stage space” (Howard, 2010, p. xxiii). Scenarization of the experience in science centres have been developed within a “black box” paradigm (Toon, 2005). The interior intentionally obscures the outside world, placing the visitor in an artificial environment created by the exhibition designer. There has been more focus on the scenography of exhibition spaces such as experimentation with the creation of different moods and characters of space. Driving factors in this shift have been greater emphases on the visitor, higher audience expectations, and acknowledgment that design has a bigger role to play.

2.8 CONCEPT OF VISITORS' BEHAVIOUR IN THE EXPERIENTIAL ENVIRONMENTS

The next section highlighted some of the related concept of visitors' behaviour in an experiential setting applicable to science centre environments.

i. Relationship between Texture and Participation

Texture reflects the qualities of a context that can create an intense sensory encounter (Firat & Dholakia, 1998) and plays a significant role in consumers' creation and assessment of experiences derived from the encounter. In many experiential settings, encountering the possibilities of transformation of the mundane to a more attractive, dimensional, as well as being able to live these modes in a safer manner (Beardworth

& Bryman, 1999) grab consumer's interest at a higher level and motivate him/her to engage more, and actively partake in the encounter. An example of experiential settings that visitors are enthusiastic about and willing to participate in, are museums that theatriticize the brand by staging the retail spectacle to be an engaging, interactive, and participatory experience (Hollenbeck et al., 2008). Sensations that are produced as the outcome of texture (qualities of a context) have powerful symbolic effects on consumers (Lanier & Hampton, 2009). Accordingly, sensory excitement or thrill is an important driver of consumer behaviour in experiential marketing settings (Pine & Gilmore 1999, and Wikström, 2008). Some experiential contexts attract people to be engaged, to make them a part of the setting. Different layouts and interior design of an encounter influence consumers' behaviours and emotions in different ways (Wasserman et al., 2000).

ii. Relationship between Texture and Immersion

Researchers have found that ambiance factors such as music, lighting, and colour affect customers pleasure and arousal emotions in these settings (Pullman & Gross, 1994). Consequently, presentation of affective sensory stimuli is found to play a key role in evoking positive emotional responses (Finkelstein, 1989). Specific sensory designs, for example special effects, that consumer environments play out in consumers' minds and bodies, are proposed to be among the most memorable aspects of these contexts (Lukas, 2007). They are about enhancement and exaggeration of sensation and thus allow consumers to have full sensory connection with the context. Immersion is largely a result of contemporary consumer environments' sensory landscapes that coordinate and situate the ideal and the real. Experiential consumer environments provide a physical context to mythical narrations that enhance their sensual impacts (Gupta & Vajic, 2000). The physical context that supports the mythical narrations through various sensory stimuli makes consumers immerse even deeper into the context. Texture in the contemporary culture is highly related to technological production techniques that produce illusion and spectacles (Featherstone, 1995). In a discussion on creation of theatre effect online through technology, Laurel (1991) argues that tight linkage between visual, kinaesthetic, and auditory modalities is the key to the sense of immersion that is created by many computer games, simulations, and virtual-reality systems. Special effects that are created with this same logic in physical marketing environments allow consumers' full sensory contact with the context. These types of effects are an important aspect of quality production values of a well-crafted spectacle, which is also essential to arousing the emotions of experiential customers. (Kozinets et al., 2002). Lukas (2007) argues that themed spaces as key contemporary consumer environments that utilize advanced technologies are effectively designed to engage consumer's senses, and therefore they are immersive geographies. He further asserts that the range of senses deployed in such settings indeed guarantees an immersive experience (Lukas, 2007). Overall, consumers sense a higher level of immersion as a result of their higher level of participation due to the higher level of attractiveness and multidimensionality that stem from these affective sensory stimuli (Beardsworth & Bryman, 1999).

iii. Relationship between Participation and Immersion

What people live through in an experiential context is always mediated through the body and its active engagement with and sensing of a material environment through the auditory, visual, olfactory and tactile perception systems (Bærenholdt et al., 2008). Participation significantly influences consumer's cognitive and behavioural responses (Coulter, Price, & Feick 2003). In gameplay studies, it is found that different types of immersions are defined based on the involvement of game players on different emotional, physical, cognitive, and sensory dimensions (Ermi & Mäyrä, 2005). The more consumers are involved in an encounter - whether emotionally, physically, cognitively, or, socially - the closer they are to a sensation of total immersion (Brown & Cairns, 2004).

The degree of immersion of a consumer may be related to his/her level of engagement in various elements of the encounter (Sherry et al., 2007). When consumers engage highly in the context, their senses and mind are challenged (Darmer & Sundbo, 2008). The more a consumer engages actively with his/her senses, feelings, imaginations, or thoughts, the higher-level s/he is expected to internalize and connect to the context at a level to perceive it as the reality. In other words, as immersion indicates the internalization of the elements of a context; active participation of consumers is expected to increase immersion since it is the key determinant of a successful internalization process.

Immersion refers to a transition from being a detached subject to becoming one with the event/activity and the context within which the event/activity takes place (Featherstone, 1991). Similar to the approach taken by Featherstone, Pine and Gilmore (1999) consider immersion as the opposite of absorption, and define it as an outcome of becoming physically (or virtually) a part of the experience itself. According to them, consumers go into the experience actively through active partaking, rather than being passively absorbed in an event to have the connection at the fullest. Immersion, thus, is the central element that places the experience as the valued market offering that engages consumers in the creation process (Fırat & Venkatesh, 1995, Cova 2005, and Carù & Cova, 2007).

Klingmann (2007) emphasizes the significant part the architecture can play in determining the ways and the level of consumer's participation, and in return their immersion. She asserts that architectural design elements work as catalysts for new experiences and participation by creating sensation, which results in an enraptured mood of the consumer. Kozinets (2002) contend experiential contexts largely utilize “interactive displays and other engaging edifices that evoke emotions and other sensations that make an experience unique and individual". This uniqueness and individuality perceptions of the experience that results from high level of evoked emotions and sensations created through participation in return creates a feeling of attraction. Research by Hollenbeck et al. (2008) shows that “when brand museum visitors participate in multisensory, interactive experiences, they are drawn to the brand". When consumers participate in an encounter, it is easier for them to be enveloped by the unique reality created in that context. The vividness of a context for a consumer thus stems largely from participation. The higher the consumers participates the higher level of contextual reality they perceive. And consequently, they become one with the contextual elements as these elements become their realities. According to Baker et al. (1992), an environment that offers a high level of atmospheric characteristics which provides a pleasurable experience for consumers can be created by utilizing social factors. This is the primary reason for marketers designing encounters in which consumers can socially participate. This participation largely determines the immersive dimensions of the context and consumers’ immersion levels into the environment. Table 2.6 summarises the concept of visitors' behaviour in the experiential environments which is applicable to science centres.

Table 2.6

	Relationship between Texture and Participation	
1	Texture: • Reflects the qualities of a context that can create an intense sensory encounter. • Plays a significant role in consumers' creation and assessment of experiences derived from the encounter.	Dholakia and Fırat (1998)
2	Motivation to engage and participate in the encounter: • Encountering the transformation of mundane to a more attractive and dimensional. • Being able to live these modes in a safer manner in many experiential settings.	Beardworth and Bryman (1999)
	Relationship between Texture and Immersion	
1	Ambiance factors that affect customers pleasure and arousal emotions: • Music • Lighting • Colour	Pullman and Gross (1994) Baker and Cameron (1996)
2	Sensory designs: • Special effects, are the most memorable aspects of these contexts. • Enhancement and exaggeration of sensation. • Allow consumers full sensory connection with the context.	Lukas (2007) Gupta & Vajic (2000)
3	Presentation of affective sensory stimuli play a key role in evoking positive emotional responses.	Finkelstein (1989) Scapp and Seitz (1998) Hanefors and Mossberg (2003)
4	Linkage between visual, kinaesthetic, and auditory modalities is the key to the sense of immersion created by computer games, simulations, and virtual-reality systems.	Laurel (1991)
5	The range of senses deployed in themed spaces guarantees an immersive experience (Lukas 2007).	Lukas (2007)
6	A higher level of immersion is a result of higher level of participation due to the higher level of attractiveness and multidimensionality that stem from affective sensory stimuli.	Beardsworth and Bryman (1999)
	Relationship between Participation and Immersion	
1	Participation significantly influences consumer's cognitive and behavioural responses.	Coulter, Price, and Feick (2003)
2	The more consumers are involved in an encounter - emotionally, physically, cognitively, or socially; the closer they are to a sensation of total immersion.	Brown and Cairns (2004)
3	Immersion refers to a transition from being a detached subject to becoming one with the event/activity and the context within which the event/activity takes place.	Featherstone (1991)
4	Immersion is the opposite of absorption.	Pine and Gilmore (1999)

	An outcome of becoming physically (or virtually) a part of the experience itself.	
5	Immersion is the central element that places the experience as the valued market offering that engages consumers in the creation process.	Fırat and Venkatesh (1995) Cova (2005) Carù and Cova (2007)
6	Architecture determines the ways and the level of consumer's participation, and their immersion. Architectural design elements work as catalysts for new experiences and participation by creating sensation.	Klingmann (2007)
7	A high level of atmospheric characteristics which provides a pleasurable experience for consumers can be created by utilizing social factors.	Baker et al. (1992)

2.9 CONCEPT OF REPRESENTATIONAL SYSTEMS IN SCIENCE CENTRE ENVIRONMENTS

The next section highlighted the related concept of representational systems in science centre. It is a rational group that tends to shape both the epistemological and the pedagogical message of a science centre. Epistemology relates to the theory of knowledge, especially with regard to its methods, validity, and scope. It is the distinction between justified belief and opinion. These epistemologies and the pedagogy messages are either explicitly or implicitly communicated to a visitor through a process called synesthesia, meaning that all his/her senses take part in their reception (Kress and van Leeuwen, 2001). Data using analytical template (Koulaidis et.al.,2002) were systematically coded to identify:

i. The types of epistemological relationship between knowledge categories.
ii. The degree of abstraction, elaboration and specialization.
iii. The locus of control over the communication established by the exhibits.
iv. The social relations within the context of a science centre.

Table 2.7
Functions of all the representational systems employed in a science centre

Representational system	Classification	Formality	Framing
Written language	•	•	•
Text formatting and layout		•	
Twodimensional representations	•	•	•
Threedimensional representations	•	•	•
Sound		•	•
Lighting		•	•
Degree of linearity			•

Sources adopted from (Koulaidis et al.,2002)

2.9.1 Three-dimensional representations

i. Classification (content specialization)

The three-dimensional representations contribute to the level of classification and hence to the degree of the content specialization of the techno-scientific knowledge projected by a science centre. In specific the content specialization promoted by the three-dimensional representations is determined by:

1. The form
2. The function of each representation

The forms are distinguished into conventional, hybrids and realistic ones. All representations that represent reality in a codified way are considered as conventional. These representations are constructed according to the techno-scientific conventions and are usually graphs, maps, flow-charts, molecular structures and diagrams. Hybrids are usually conventional representations with added on realistic features. Finally, all the representations that exhibit reality according to human optical perception are considered as realistic. In relation to their function the representations are divided into classificational, analytical, narrative and metaphorical (Kress and van Leeuwen, 1996). Classificational representations are those that exhibit type of relationships between the represented entities or to put it differently, a taxonomy. Narrative representations are those that represent ‘unfolding actions and events, processes of change and transitory spatial arrangements’ (Kress and van Leeuwen, 1996). In this kind of representations, the represented action is visualized by a vector, either shown explicitly or imaginarily implied. Analytical representations are those that focus on the relations between the ‘objects’ of representation in terms of a part-whole structure. The parts of the whole may be labeled or it may be left up to the viewer to do so. Finally, metaphorical representations are those that ‘connote or symbolize meanings and values over and above what they literally represent’ (Kress and van Leeuwen, 1996). Table 2.8 describe the way that all the above elements of the three-dimensional representations modulate the level of classification.

Table 2.8
Classification modulation by the three-dimensional representations

Representational characteristics	**Strong classification**	**Weak classification**
Form	Conventional representation or hybrid	Realistic representation
Function	Classificational, Analytical, Narrative	Metaphorical

ii. Formality (codes’ specialization)

The three-dimensional representations contribute to the level of the exhibits’ abstraction and hence to the level of their formality. The more an image represents the deeper ‘essence’ of what it depicts by downgrading the superficial variability of their external features the higher is its formality. This is accomplished by reduced articulation. Low formality then, corresponds to representations very close to realism while high formality corresponds to techno-scientific realism that defines reality in terms of what things are like generically or regularly (Kress and van Leeuwen, 1996). The formality of the representations can be estimated using relevant markers. These markers record particular constitutive elements of the representations that contribute to their level of abstraction (degree of articulation). The markers used to evaluate the formality of the three-dimensional representations are: the presence of elements of the techno-scientific code (geometrical shapes, vectors, etc), colour differentiation, colour modulation, degree of articulation of their background, part of the three-dimensional objects represented and their texture. For example, a three-dimensional representation of globe, which is relief, appears as a whole, without built-in elements of the techno- scientific code and characterized by the use of multiplicity of colors and color shades (e.g. deep blue for the points of large oceanic depth) can be considered as a three- dimensional representation of low formality. On the contrary, a globe appearing in half (as if it was shown from the moon), monochromatic, with a flat surface and with added on elements of the techno-scientific code (e.g. arrows representing the oceanic draughts) can be characterized by high formality. In Table 2.9 that follows, the individual characteristics that modulate the level of formality of three-dimensional representations, are presented.

Table 2.9
Formality modulation by the three-dimensional representations

Representational characteristics	**High formality**	**Low formality**
Colour differentiation	One or two colours	Three or more colours
Part of the object represented	Partial representation	Full representation
Texture	Flat surface	Relief surface

iii. Framing

The three-dimensional representations tend to contribute to the regulation of the interpersonal/affective relationships between the exhibits and the visitors. The corresponding characteristics are the exhibits' size and the vertical angle of view. The degree of a visitor's involvement with what is represented in the images as a measure of his/her potential to participate in the communication process, is visually realized by the distance and the horizontal angle of shot. More particularly, the distance of shot regulates the level of intimacy that is possible to be established between what is represented and the visitor and takes the values of close, medium and distant shot that correspond to an intimate/personal, social and impersonal relationship respectively (Meyrowitz, 1986). The horizontal angle of shot signifies the degree of involvement that the visitor can have with the represented agents and takes the values of frontal and oblique angle. 'The difference between the frontal and the oblique angle is the difference between familiarity and detachment' (Kress & van Leeuwen, 1996). The corresponding characteristics for the case of the three-dimensional representations are the minimum distance that a visitor can approach each representation and the horizontal angle of view.

For example, a three-dimensional representation of a celestial body that is large in size, can be viewed from a high and oblique angle and which cannot be touched, tends to create a feeling of diminishment and alienation of the visitor and hence promotes strong framing. On the contrary, a three-dimensional representation of a molecular model of human-like size, which can be viewed at the eye-level and frontally and which can be also manipulated by a visitor tends to create a feeling of familiarity and call for involvement and hence promotes weak framing. In Table 2.10 below, all the individual characteristics that modulate the level of framing for the three-dimensional representations are shown.

Table 2.10
Framing modulation by the three-dimensional representations

Representational characteristics		**Strong framing**	**Weak framing**
1. Power relationships	Vertical angle of view	Viewed from below	Viewed at eye-level or from above
	Size	Large	Human like size or less
2. Visitors' involvement	Horizontal angle of view	Side view	Frontal view
	Minimum distance of approach	Visitor can only see but not manipulate the exhibit	Visitor can manipulate the exhibit

2.9.2 Lighting

Light and colour are major determinants in defining the overall character of a space. Colour alone constitutes the major basis of our visual assessments and subconscious responses (Meerwein et al., 2007; Singh, 2006; and Yüksel, 2009). Moreover, beyond light's role in enabling the perception of colour, its role in and of itself may be underestimated since light is usually registered subconsciously in the context of a broader visual assessment (Boyce, 2004; Custers et al., 2010; and Meerwein et al., 2007). Most lighting research has focused on utilitarian requirements such as task visibility and avoidance of visual discomfort and fatigue. By contrast, the psychological and particularly affective impact of artificial lighting has been a relatively unexplored field (Boyce, 2004). While lighting has been found to play a role in influencing perceptions of interior spaces such as retail environments (Custers et al., 2010; and Turley & Milliman, 2000), the contribution of lighting to the creation of an overall atmospheric mood is less well understood. A complicating factor is distinguishing between lighting's atmospheric role and its purpose on a more utilitarian level (Areni & Kim, 1994). Lighting in a science centre can modulate both the level of abstraction of the exhibits and hence the level of the exhibits' formality and the range of options available to the visitors and hence the level of framing.

i. Formality

Abstraction in this case is again accomplished by reduced articulation. Thus, the more elements of lighting contribute to the realistic appearance of the exhibits, the lower the formality becomes. These elements are: the realism of the colours of lighting, the colour differentiation as well as the degree of directionality of lighting. The more realistic and differentiated are the colours of lighting and the more diffuse is the light that falls on the exhibits the lower the formality. On the contrary, a well-known technique very often employed in the science fiction films is the use of unrealistic and usually monochromatic lighting which takes the form of very narrowly focused light beams. This technique creates a futuristic and technocratic atmosphere that signifies high levels of formality. In Table 2.11 presents all the lightning properties that modulate the level of the exhibits' formality.

Table 2.11
Formality modulation by lighting

Representational characteristics	**High formality**	**Low formality**
Degree of colors realism	Unrealistic colors	Realistic colors
Color differentiation	One or two colors	Three or more colors
Degree of directionality	Focused light beams	Diffuse lighting

ii. Framing

Lighting can also modulate the level of framing projected by a science centre. The lighting property that plays a crucial role in determining the level of framing is the intensity of illumination of an exhibit in relation to the corresponding intensity of the surrounding exhibits. In specific, when the illumination of an exhibit is more intense in comparison to the illumination of its surrounding exhibits then it becomes more prominent and so in an implicit way forces the visitor to draw his/her attention to it. In this way, lighting reduces the visitor’s control and hence leads to strong framing. On the contrary, when an exhibit is not more intensely illuminated with respect to its surroundings, there is no implied hint to the visitor to draw his/her attention to it and hence the framing is weak. In Table 2.12 below, the way lighting can modulate the level of framing is shown.

Table 2.12
Framing modulation by lighting

Lighting property	**Level of Framing**	
	Strong	**Weak**
Intensity of lighting with respect to the surroundings	More intense lighting with respect to the surroundings	Uniform lighting everywhere

2.9.3 Degree of linearity

The composition of all the exhibits in a science centre as a whole constitutes a separate representational system carrying its own semiotic semantics. The prevailing feature of this composition that will be examined here is the degree of its linearity. The degree of linearity reveals the strength of each exhibit' connections to the other exhibits. This strength can be estimated by the existence of signs of explicit or implicit (e.g. morphological features such as common color, background or lighting) reference to other exhibits, the proximity between the exhibits as well as the presence of connective elements such as the numbering of different parts of an exhibit or of a group of exhibits.

For a specific exhibit, low linearity grade means that it can be accessed in a rather independent way without the need to refer to any other exhibit. A high linearity grade means that an exhibit is tightly linked to one or more other exhibits and so the visit must follow a prescribed path in his/her tour around the science centre. As a result, the more a science center contains exhibits with a high linearity grade, the more the visitors have to comply with a specific path of navigation during their visit and the more the exhibition tend to be characterized as a linear one.

In this case the visitor has restricted control and hence framing is strong. On the contrary, the less linear a science center is, the more a visitor is allowed to navigate it in a multiplicity of ways and hence the promoted framing is weak. In Table 2.13 below, the way the different elements that contribute to the degree of linearity of an exhibit modulate the level of framing is shown.

Table 2.13
Framing modulation by the degree of linearity

Characteristic related to the degree of linearity	**Level of Framing**	
	Strong	**Weak**
Reference to other exhibits	Explicit or implicit reference	No reference

Proximity	Close or overlapping with other exhibits	Segregated and distinct from the other exhibits
Connective elements	Existence	Non-existence

2.10 THEORETICAL FRAMEWORK

The literature discussed in the previous sections revealed a variety of theoretical perspectives and research methodologies which underline the theoretical framework of this study. The perspectives on issues pertaining to experiential learning theory is important in understanding the concept of exhibition design particularly to facilitate learning in unstructured or informal learning environments. This research seeks to explore the matter used in designing and developing exhibitions to promote learning, visitor experience and interaction. This research is underpinned by the idea that learners construct their own knowledge. The look, feel, placement, and other environmental aspects of exhibition - combined with the learner's own perspective - serve to promote construction of knowledge and enhance the visitor's experiential learning (Bruner, 1986, Dewey, 1983, Duffy & Cunningham, 1996, and Falk & Dierking, 2000). The theoretical framework of this research is developed based on the following:

1. Kolb's theory on Experiential Learning.
2. Falk and Dierking's theory on the Contextual Model of Learning.
3. Shedroff's theory on Experience Design.
4. Kotler's theory on Atmospherics.

How science centre as part of a museum attempt to foster constructivist and experiential learning by providing informal educational opportunities (Duffy & Cunningham, 1996; Falk & Dierking, 2000; Grabinger, 1996; Hein, 1998; Schauble et al., 1997; Leinhardt et al., 2002; and Weil, 2002) through exhibitions is the basis of the study.

This study explores possible factors and design decisions that influence informal learning and knowledge generation in a science centre setting. This research draws upon existing theory regarding how people perceive and respond to environments and applies it to the museum context. The underpinnings of museum exhibitions began with the Experiential Learning theories (Kolb, 1984). The increasing emphasis on exploration, reflection, interaction and environments for learning can be attributed to Dewey's (1933) thinking related to the formation of knowledge. The principle of interaction is grounded in the notion that the conceptions of situation and interaction are inseparable. Kolb recognized the continuity of personal experience; the relationship between a learner's context and their way of learning. In a museum setting, this means that the museum environment influences a visitor's meaning making.

Based on Kolb's experiential perspective, learning is "…the process whereby knowledge is created through the transformation of experience"(1984, p.38). Kolb identify two major dimensions of learning: perception and processing. Perception ranges from concrete experience to abstract conceptualization, and processing ranges from active experimentation to reflective observation. The two axes form a four-quadrant field for mapping individual learning styles. The intersection of the processing and perception dimensions creates a set of learning styles which emphasizes how people like to interact with learning content. Kolb's characterization of the modalities of engagement guide the exhibit developers in shaping an activity's structure to support these modalities.

Falk and Dierking's theory on the Contextual Model of Learning introduced a framework related to the gestalt psychology of the museum experience. Gestalt psychology is the study of the perceptual relationships between parts and wholes, where the whole has emergent properties that transcend those of their component parts. In other words, it is not just individual components of a scene, but their grouping and juxtaposition that will influence what is perceived. Gestalt psychology posits that perception is an intrinsically holistic phenomenon (Wagemans, Elder, et al., 2012; Wagemans, Feldman, et al., 2012). While the methods and conceptual inferences of the early gestalt psychologists were discounted by the mid-20th century, gestalt principles regarding perceptual groupings and hierarchies continue to influence the study of environmental appraisal and visual processing more broadly (Wagemans, Elder et al., 2012).

The Contextual Model of Learning emphasizes visitor expectations and the importance of how a museum exhibit, the implications of the personal context and sociocultural context in the museum experience. Visitors' learning is influenced by the design - when exhibitions are appropriately designed, they become one of the best educational mediums and learning tools (Falk & Dierking, 2000). The theory provided an insight of the relationship between providing control over learning. The presence of choices and opportunities to be engaged in meaningful activities is dynamic according to the different themes, which requires specific conditions of the physical setting.

Shedroff's theory on experiential design is an approach to creating optimal experiences for people in any medium. He asserts that experiences consist of four stages: attraction, engagement, conclusion and extension. Shedroff suggested concepts such as immersion, metaphors, authenticity, interactivity, sensory exploration and adaptivity which designers can explore when designing for great experiences. He emphasized the need to explore new research methods that understand people beyond issues of usability, such as methods that address human needs from emotional and social perspectives.

For the purposes of clarity, in this thesis atmospherics will pertain to the sensory aspects of that environment. This is consistent with Kotler’s original definition of atmospherics as being primarily a sensory phenomenon (Kotler, 1974). In particular, it is based on the study of how design characteristics of a service setting influence customers' perceptions and subsequent behaviour. It is the design elements of the exhibition atmosphere that are of interest to this study. This research explores the sources in science centres that evoke visitor emotions, and identify design opportunities in both tangible elements and intangible processes for enhancement of visitor experiences.

Both atmospherics and existing research into the museum visitor experience have been strongly influenced by the theories and techniques associated with environmental psychology (Bitgood, 2002, 2011; and Ng, 2003). Environmental psychology is the study of the interplay between people and their environment, where the environment is understood to comprise both physical and sociocultural elements (Holahan, 1982; McAndrew, 1993). Psychological responses to this environment (e.g., perceptual, cognitive, affective) mutually interact and affect behaviour. Applying these principles of environmental psychology to the museum environment, the visitor-exhibition dynamic can be considered to unfold in space and time as the visitor interacts with cues in the exhibition environment (Bitgood, 2011; Falk & Dierking, 2000). The theoretical framework proposed for this study is centred on these main issues:

1. Atmospheric context and experiential learning.
2. Enchantment as a tool of message in the museum experiences.
3. Representational modes as the source that generate visitor responses.
4. Design opportunities affect representational modes and enchantment in the museum experiences.

Atmospheric context inspires experiential learning in exhibitions. Factors such as layout, exhibit location, three-dimensional form, colour and lighting do affect museum experience. Besides atmospherics, this study assert that enchantment also influence the experiential learning in science centre. Enchantment is a feeling of great pleasure, delight or being captivated. Enchantment is to support affective dimension in learning and shape the museum experience. Enchantment can be trigger through thematization, spatialization and scenarization. As highlighted, thematization is defined as the patterning of space, activity or event to symbolize experiences. Spatialization is the physical environment in which the visitor experience occurs, through definition of the architecture, decoration and the general atmosphere of the place. Scenarization is the considerations about scenography. Resources are expended in the design of exhibitions, with a growing emphasis on the creation of environments with immersive, themed, and theatrical elements.

While science educators considered visitors' need to learn through different senses, designers pay more attention to the ambience of the entire exhibition setting and contemplate how the ambience can have an impact on visitors' perceptual, sensory experiences and level of understanding. Hence, there is an inseparable association between design and the visitor experience. Design influence visitor participation with different emphases on science centre representational modes as suggested by Koulaidis et.al (2002). The representational modes include three dimensional representations, lighting quality and degree of linearity. In this study, the variety of three dimensional representations is dependent on functions and forms, colour differentiation, colour modulation, parts of the objects represented, texture, vertical angle of view, size, horizontal angle of view and minimum distance of approach. The variety of lighting quality is dependent on degree of colours realism, colour differentiation, degree of directionality and intensity of lighting with respect to the surroundings. The variety on degree of linearity is dependent on reference to other exhibits, proximity and connective elements. This study argues that analyzing these representational modes facilitate understanding on experience design in museum.

Design can influence positive affect and thus help foster a mind-set that is conducive to discovery, exploration and learning. Research into relation of exhibition design and learning processes is important to understand the conditions that facilitate an enjoyable and productive learning experience as suggested by Packer (2006). Strong narrative and attention to the atmospherics or exhibition staging, have the capacity to transform visitors on an emotional level (Yellis, 2010). However, the changes in atmospheric context and enchantment to a certain extent are expected to be influenced by the design opportunities available in the science centre. The framework of this study is confined to the interrelationship between the concept of atmospheric context, enchantment and design opportunities in science centre. This interrelationship affects the experience design of museum. As suggested by Dewey (1933), in a museum setting, the museum environment influences a visitor's learning. Visitor will take individual meaning from exhibitions based on their own previous experiences and their present experience in the museum. Thus, the level of experiential learning achieved depends on individual museum experience and the experience design as shown in Figure 2.5.

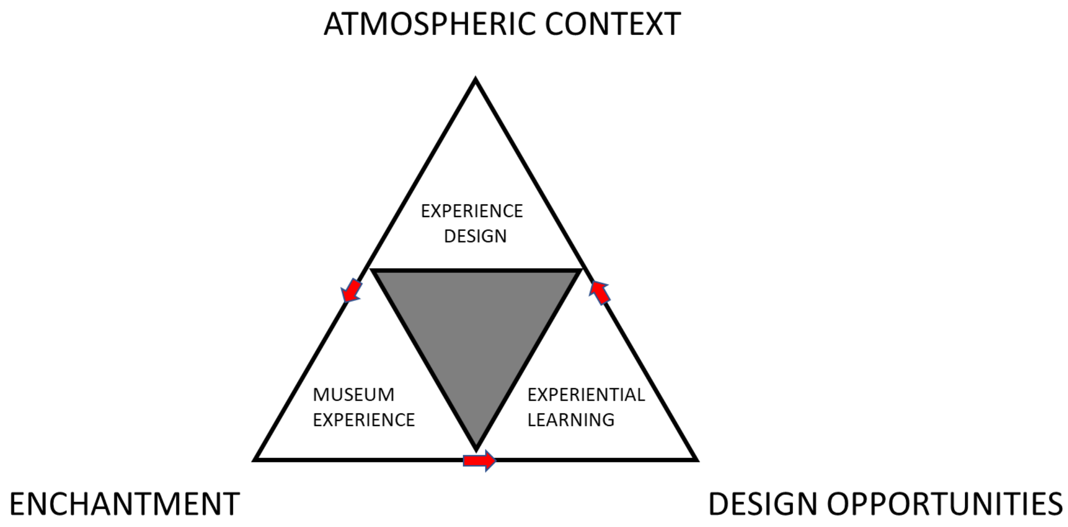


Figure 2.5 Theoretical Framework of the research

2.11 SUMMARY

As science centre is undergoing a shift towards experience-based offerings for competitiveness, staging pleasant and memorable experiences is becoming indispensable. The experience in a science centre is unique so as to generate a strong affective outcome. An experiential factor through design communication therefore, is to influence participation and immersion of science centre visitors. Experiential learning theory is important in understanding the concept of exhibition design particularly to facilitate learning, especially in informal learning environments. Self-directed learning that occur in a science centre is reinforced by being multimodal to cater for different learning preferences. Other related learning theories has also provided an underlying understanding of the relationship between providing control over learning. The presence of choices and opportunities to be engaged in meaningful activities is dynamic according to the different themes which requires specific conditions of the physical setting. Falk & Dierking (2013) use a Contextual Model of Learning in museums, consisting of the personal (a variety of experience and knowledge), the sociocultural (culture and social interaction) and the physical context (architecture, design, ambience, both physical and virtual), pointing out that learning occurs in the intersection of all three.

Studies show that the style of the exhibit presentation deeply affects the kinds of thinking engaged in by visitors. The cognitive and affective impacts of visiting science centre can be supported by analyzing science centre as ‘texts’ that employ a variety of semiotic modes in constructing their messages. It is a ‘textual’ analysis in relation to the epistemological and the pedagogical implications of the exhibits’ design. Research interest is also expanding to the broader context of people’s experiences. Experience design is a holistic approach to design that focuses on the in-depth understanding of users and the synthesis of multi-disciplinary knowledge for optimal design outcomes. Atmospheric studies support the notion that changes in the environment can lead to apparent changes in both attitudes and behaviour. The literature shows that experiential learning principles, enchantment and atmospherics are applied in design research on visitor experience and exhibition design. The research reported in this thesis uses these variable concepts as a theoretical underpinning to guide data analysis for design research. The communication process and the levels of autonomy in initiating, continuing or redirecting visitor's own learning is an important characteristic of the pedagogical framework in a science centre. A sense of self-determination and control over the projected knowledge can support the investigative, playful and exploratory nature of science.

CHAPTER 3

RESEARCH METHODS

3.1 INTRODUCTION

This chapter presents detailed explanations of the rationale and procedures of the processes used for this research. It is divided into three sections. The first section presents an overview of research processes of the study and methods in the study of science centres and experiential design. This is concluded by the selection of methodologies employed for the study. The second section detailed the research methodology for the present study namely case study, observation through photographic medium and in-depth interviews. The data analysis is presented in the following section followed by the conclusion of the chapter in the last section.

3.2 DEVELOPMENT OF RESEARCH QUESTIONS

Informal enquiries were conducted to solicit opinions from science centre professionals regarding the issues of experiential design, experience and informal learning in science centres. The purposes of the enquiries were threefold - to learn about trends and concerns of the institution in relation to visitor experience and to discover design related issues of science centre interest. These enquiries were exploratory in nature and they were conducted as part of the work that facilitated the refinement of research focus and development of research questions. The interviewees included several science centre professionals, participants of the 13th Annual Conference of Asia Pacific Network of Science & Technology Centres (ASPAC 2013 Conference) in Korea. The topics discussed during the preliminary enquiries focus on the forces shaping the cultural institution. This include the goals that the institutions are trying to achieve, the recent trends of science centre development, the exhibition design current practices, visitor accommodations and educational value. Enquiries in ASPAC 2013 Korea influence the thesis scope in signifying the need to understand the function and design aspects for science centre exhibition design success. The institutions' new challenges, visitors' needs, high expectations and educational value were highlighted. The enquiries were follow-up through e-mails. A set of open-ended questionnaires was developed (Appendix I) focusing on issues related to the relation between place and emotion, the science centre strategies and needs, suggestions about improvements of science centre, major factors affecting fun learning experience, recent trends of science centre development, goals to be achieved by the institutions, major problems faced by science centre and fruitful direction for PhD research. In summary:

1. Why is science centre providing experiences in general?

   This question overviews the relation between place and emotion.

2. What are the strategies to provide an experience?

   This question focus on science centre strategies and needs.

3. What is science centre new exhibition experience?

   This question query on suggestions about improvements of science centre.

4. How is science centre providing experiential exhibits?

   This question direct on major factors affecting fun learning experience.

5. Making the scientific issue more "experienceable".

   The comments on recent trends of science centre development

6. Benefits as an informal learning tool.

   Discuss on goals to be achieved by the institutions.

7. Limitations of science centre experience.

Understanding major problems faced by science centre and fruitful direction for PhD research.

The literature review was also conducted as part of the work that facilitated the refinement of research focus and development of research questions. The literature suggests that visitors interacts with atmospheric stimuli on different levels and for different purposes. Visitors appropriate servicescape for their own needs and agendas that do not necessarily correspond to curatorial or managerial objectives and therefore criteria for an exhibition's success should be framed accordingly (Rounds, 2004). These remarks served as the starting points for exploring the atmospherics in science centre, as well as discovering design criteria for optimal visitor experiences.

Based on findings from preliminary enquiries and literature reviews, the study focusses on three directions: (1) informal learning in science centre experience; (2) science centre exhibitions and (3) Design criteria for science centre exhibition's success. Based on these directions, the researcher proceeded to select the science centre, the potential research participant and specify the research questions. The science centres chosen as the case studies must have the criteria of quality standard exhibition design as well as offering integration of a variety of new exhibits within its exhibition environment. Science centre professionals are chosen as the research participant of this research to explore the relationship between informal learning and design quality of exhibitions. After refining the research focus and target segment, the research addresses specific research questions on design opportunities that will enhance visitor experiences in science centre.

3.3 RATIONALE FOR QUALITATIVE RESEARCH APPROACH

The match between the research problem and the research approach is the most important consideration when deciding on an appropriate research approach (Creswell, 2003; and Corbin & Strauss, 2008). Two main characteristics of the research questions in this research call for a qualitative methodological approach: (i) the exploratory nature of this research; and (ii) the research focus on people's experiences. The rationale about the fit between research questions and the qualitative approach is elaborated below.

i. Exploratory Research

The qualitative methodological approach is particularly suitable for discovery-oriented research that aims at exploration and explanation instead of hypothesis testing (Walsh, 2003; David & Sutton, 2004; and Creswell, 2007). The research questions addressed in this research show the flow of discovery-oriented inquiry. The research begins by identifying the tools for enchantment of the science centre experience and where these sources occur in science centre. Next, the interconnection between its representational systems and enchantment of the science centre experience is elaborated. Based on insights from the first two research questions, the research then proceeds towards identification of design opportunities that will enhance visitor experiences in science centre. This flow indicates that the nature of this research is exploratory in the sense that it aims to discover insights and opportunities for application instead of testing hypothesis or predictive proposition. As the emphasis is on discovery, a qualitative methodological approach is appropriate for answering the research questions.

ii. Focus on People's Experiences

Qualitative methodological approach is ideal for studying people's experiences because of its exploratory and explanatory nature. Qualitative research allows researchers to get at the inner experience of participants, to determine how meanings are formed through and in culture, and to discover rather than test variables (Corbin & Strauss, 2008) Patton (2002) also contended that the qualitative approach is particularly suitable for "inquiry into the meanings people make of their experiences". This is because qualitative approach often emphasizes the interpretation of meanings people bring to the phenomena under study (Denzin & Lincoln, 1994).

Design research that focuses on improving visitor experiences usually relies heavily on detailed insights about context and visitor behaviours. These insights are needed to increase designers' empathy. Visitor behaviours was not discussed in particular, as the subjects of inquiry are process based and goal oriented. Interview becomes the most straightforward way to learn about useful information from the research targets. As such, contextual information obtained through some forms of direct or indirect observation is necessary, and direct conversations are necessary.

3.4 QUALITATIVE RESEARCH PRINCIPLES

There is a great variety of types and traditions of qualitative research. For example, Creswell (2007) explained five key traditions in detail, Denzin and Lincoln (2005) identified nine key strategies, Wolcott (2001) examined 19 in a tree format, and Tesch (1990) reviewed 26 types of qualitative research. The nature of this research's specific questions and objectives reflects elements from more than one type or tradition of qualitative research. The goal of this research is to contribute to design knowledge, the "grounded theory" approach would be useful as it builds theories from inductive analysis based on interpretation of themes that emerge from the data (Glaser & Strauss, 1967; Strauss & Corbin, 1990; Charmaz, 2006; and Corbin & Strauss, 2008). The literature of qualitative research details on each principle are discussed below. The ways these principles apply to this research are explained.

3.4.1 Purposive sampling

Purposive sampling is one of the principles of qualitative research that guide this research. The idea behind purposive sampling is to purposively select participants or sites that will best help the researcher understand the problem and the research question (Creswell, 2003). Case studies are selected because they are information-rich and illuminative. They offer useful manifestations of the phenomenon of interest (Patton, 2002). Sampling is aimed at insight about the topic area under investigation, not empirical generalization from a sample to a population (Patton, 2002). In purposive sampling generalizability is less important than the collection of rich data and an understanding of the ideas of the people chosen for the sample (Holloway, 1997). It is common practice for qualitative researchers to choose certain criteria in advance of their study on which the selection of a sample is based. The sample in qualitative research is rarely large. The size for a study generally ranges from four to 40 (Holloway, 1997). The sampling methods are a combination of criterion sampling and chain-referral sampling. Sources for recruiting participants and specific sampling procedures are discussed later in this chapter.

3.4.2 Open-ended, narrative-rich data

Qualitative research studies give emphasis to the collection of primarily non - numerical, open-ended data. The types of data often include thick descriptions, verbal data through interviews, the use of written or other forms of records, images, or artifacts (David & Sutton, 2004). Qualitative data are also narrative-rich. Tesch (1990) noted that when we ask questions about human affairs, the responses come in sentences, not numbers. We collect as 'data' narratives". Patton (2002) commented that researcher capture and communicate someone else's experience of the world in his or her own words. This research focuses on experiential design for science centre visitor have 'data' as open-ended, narrative-rich and contextual in nature. The in-depth interview based on a list of open-ended questionnaires enables the researcher to collect narrative-rich data in the form of experiential accounts of visitor interaction with the exhibitions. To better capture research participants' experiences, it is beneficial for qualitative studies to include the collection of contextual data, or "local groundedness" (Miles and Huberman, 1994) which refer to data that were collected in close proximity to a specific situation. They contain specific cases of focused and bounded phenomenon embedded in its context (Miles & Huberman, 1994). Photographic medium study captures contextual data by direct observation. Exemplar quotes are given in the discussion of findings to convey opinion in the research participants' own words.

3.4.3 Flexibility and openness

Qualitative research is inherently flexible in the sense that research procedures and data collection can be "emergent rather than tightly prefigured" (Creswell, 2003). Because qualitative studies usually collect open-ended responses that reflect participants' perspectives and ongoing data analysis during data collection has become a near standard practice (David & Sutton, 2004), researchers can maintain a certain degree of flexibility and openness to pursue interesting ideas arising out of interaction with informants.

3.4.4 Inductive analysis

The inductive analytic approach aims at drawing concepts from the data. Corbin and Strauss defined "concepts" as: "Words that stand for groups or classes of objects, events, and actions that share some major common property(ies)" (Corbin & Strauss, 2008, p.45). Concepts represent an analyst's impressionistic understandings of what is being described in the experiences communicated by participants (Corbin & Strauss, 2008). Therefore, inductive analysis in qualitative research is inherently interpretive. The researcher makes interpretations of what he or she sees, hears, and understands (Creswell, 2007). As the researcher reads the data and organizes them into categories, he or she is going through the interpretive process of abstracting words and ideas into concepts, thus bringing out and refining the meanings that can be silted from a text, an object, or slice of experience (Denzin, 1998). In this research, the principle of inductive analysis is applied through the use of coding as the key data analysis technique. The processes involve the researcher's immersion in the data through iterative examination of data in order to identify main conceptual themes. Categories or themes for coding emerge from understanding the data instead of being predefined. The specific analytical procedures including thematic analysis, topic coding and analytical coding are further discussed later in this chapter.

3.4.5 Reflexivity of researcher

In qualitative research, the researcher constantly goes through the processes of reflecting, exploring, sifting and elucidating the nature of the phenomenon under investigation (Douglas & Moustakas, 1985). Hence it is essential for the researcher to stay self-aware and self-critical throughout all the processes of the research. Such reflexivity of the researcher increases credibility and authenticity of the study. Patton (2002) explained, "complete objectivity being impossible and pure subjectivity undermining credibility, the researcher's focus becomes balance - understanding and depicting the world authentically in all its complexity while being self-analytical, politically aware, and reflexive in consciousness". For the purpose of maintaining reflexivity in this research, notes taking is used to record insights during the research process and reflect on possible bias (Miles & Huberman, 2002).

3.5 SELECTION OF SAMPLES AS CASE STUDY

Specific examples of science centres were chosen for a variety of reasons.

1. Located at the capital city, so each receives a regular and relatively high amount of visitor traffic.

2. Quality exhibition design, offering integration of a variety of new exhibits and exhibition environment.

3. A variety of design approaches and technologies are utilized in the exhibition galleries.

4. The range of exhibitions present in the science centre implements an assortment of informal learning strategies and provides multi-sensory opportunities for visitors.

The first step for this research was deciding which science centre to use for case studies given the specific parameters.

1. The Science Centre Singapore was chosen as a case study because of the excellent reputation of many of the science centre exhibits. SCS houses over 1,000 exhibits in the 14 exhibition galleries, including the award-winning Waterworks exhibition.

2. National Science Museum in Daejeon, Korea has many exhibition galleries such as the permanent Exhibition Hall; Space Exploratorium, Science Alive

Discovery Center, Planetarium and Biosphere. The permanent Exhibition Hall has four main galleries related to: Natural History, History of Science and Technology in Korea, Basic Science and Industrial Technology.

3. The Mind Museum features 4,900 square meters of interactive science and technology exhibitions within five major galleries and outdoor spaces. With over 250 interactive hands-on exhibits, the exhibition spans nature in scale, from the smallest thing in nature to the largest and everything in between: Atom, Earth, Life, Universe and Technology. This world-class design combined with sensory-rich experiences make The Mind Museum an achievement in the museum category of Thea Awards 2014, an internationally recognized award of excellence within the themed entertainment industry.

4. Questacon is Australia's largest science centre and is prominent among the world's leading science centres. People have been inspired by engaging with travelling exhibitions, outreach and other national and international programmes. The exhibition themes highlighted here includes Questacon Foyer, Wonderworks, Q Lab, Awesome Earth, Excite@Q, H_2O Soak Up the Science and Mini Q.

5. The Macao Science Center (MSC) is a state-of-the-art educational and cultural facility. Opened in January 2010, the 23,000 square meter centre houses interactive exhibition galleries, advanced conference facilities, seminar rooms and a 150-seat planetarium. The 5,800 m2 Exhibition

Centre, in the shape of an inclined cone, contains fourteen hands-on galleries, arranged inside the building in an upward spiral accommodating a total of 450 interactive exhibits. Modulations of ceiling height, of colour and light levels, and of geometry intensify the anticipation and enjoyment of exhibits.

6. Guangdong Science Centre was chosen for its unique approach to presenting ideas. GDSC is the largest of its kind in China, with a land area of 450,000 square meters and a building floor area of 137,500 square meters. The completion of GDSC in 2008 represents an impressive example of unique architecture. GDSC contains 8 permanent exhibition halls (Children's Wonderland, Experiments & Discovery, Cyber World, Communications World, Green Homeland, Space Dreams, Human and Health, Perception and Thinking, and Digital Home), with 300 exhibits including 18 theatres.

Six science centres served as the source of case study for data, which was collected through photographic medium and in-depth interviews. As typical in qualitative studies, two levels of sampling were necessary: (1) selection of “the case” science centre and (2) selection of participants and items to analyze within the case (Merriam, 1998, p. 65). The following section describes how these science centres selection were addressed.

According to Merriam (1998) a qualitative case study is an intensive, holistic description and analysis of a single instance, phenomenon, or social unit. A purposive or purposeful sampling strategy was implemented in the selection of these science centres, in efforts to provide an “information-rich” case from which the most could be learned (Merriam, 1998; Patton, 1990). These particular science centres were selected purposefully based on several specific criteria (Merriam, 1998) or attributes: size and location, quality of exhibitions, variety of exhibition elements and the range of exhibitions. The final factor for selection was based on “convenience sampling” (Glaser & Strauss, 1967; Merriam, 1998; and Strauss & Corbin, 1990) relative to access.

A large variety of documents were also reviewed and analyzed as part of this study. External documents including brochures, exhibit maps, annual reports and other relevant materials were reviewed, analyzed and compared - particularly as related to key design ideas and relevance to visitor experiences. All of these documents provided insight into an understanding of the science centres, what it strives to do and be as an institution, and how it hopes exhibitions will play a role in its institutional goals. Refer Appendix II for each science centres background. Documentation related to the exhibition design was particularly helpful in this respect. The documentation described above, as well as researcher memoing and notes gathered during the interview process, were consulted throughout the coding and analysis phase in order to inform and guide the emergence of the themes from the study.

3.6 DATA COLLECTION METHODS

Data collection methods for this study included on site observation by technique of photography in the science centres environment and in-depth interviews with science centre professionals. The mixed methods of observation and in-depth interviews not only yields robust data, but also enables understanding of science centre atmospherics environment from both “micro” and “macro” perspectives. This is because field-based data on science centre physical context are obtained through photographic medium, while broader views about criteria for design success based on science centre curatorial and managerial knowledge, ideas and expectations can be solicited through in-depth interviews. For the purpose of clarity, Table 3.1 summarizes the two data collection methods used in this research.

Table 3.1
Summary of the two data collection methods

Method	**Observation- technique of Photography**	**In-depth Interview**
Participant	Researcher as informant	Curatorial and managerial staff from selected science centres
Procedures	• Researcher took digital photos during visits to selected science centres • Focused on capturing contextual data of architectural style, general interior atmospherics, space layout and design as well as individual exhibits and displays	• One-on-one semi-structured interview that focused on topics regarding criteria for design success
Types of data	Photograph	Verbal data from interview
Purposes	• Capture contextual data about tools on enchantment of visitor experience • Obtain data on science centre representational modes through its semiotic semantics including 3-dimensional representations, lighting quality and degree of linearity • Micro: obtain field-based data on specific cases of science centre atmospherics environment	• Understand criteria for design success based on science centre curatorial and managerial knowledge, ideas and expectations • Macro: obtain broader view about science centre exhibition design based on informants' skill and practice

Research questions (1) and (2) uses photographic analysis to bring out the symbolic dimensions specific to these cultural sites. Research question (3) uses in depth-interview to explore design criteria for science centre exhibition success.

3.7 OBSERVATION –TECHNIQUE OF PHOTOGRAPHY

This research consisted of two concurrent studies. One of the studies uses observation by photography as the key data collection method. While the other uses in-depth interviews. This section concentrates on explaining the former. In order to bring out the symbolic dimensions specific to science centre, the study develop a methodology built on visual anthropology by working on the photographic medium (Heisley, 2001; Collier, 2003; El Guindi, 2004). The photographic image must be regarded as a specific methodology to the extent that it can offer comments and provide a differentiated analysis of a given object or a similar situation (Schwartz, 1989; Holbrook, 2005). From this point of view, the photograph contains enormous argumentative and analytical potential (Becker, 1979). Observation by photography can make use of ubiquitous technology (such as digital camera) - relatively easy to use, while presenting complex details and realistic representation (Gray & Malins, 2004). Photography-based data collection methods are particularly strong in three aspects: capturing contextual information, reviving memory, and facilitating reflection (Rose, 2007). The photographs also revive the researcher of physical context, thus prevent the loss of important information. Therefore, photography is an appropriate method for this research. Observation work was conducted on the site's full offer using the photographic medium, in accordance with a rationale of being rooted in the field (Hudson and Ozanne, 1988). As photos were taken to facilitate reflection, rich contextual information allows the researcher to document what had been seen.

3.7.1 Strategy of photography-based data collection

The objective of this approach is to document the physical context of the six science centre atmospherics environment. The researcher act as informant. Visits to the six science centres were made for observation and data collection of the physical context. General information and documents regarding overall location, setting, floor plan and layout, facility amenities, and exhibits were noted. Refer Table 3.2 for summary of research methods and procedures.

Table 3.2
Summary of data collection methods and procedures

Research questions	Data collection method	Procedure
1. What are the tools for enchantment of message in the science centre experience?	Photography	Thematic analysis to understand the themes arranged by order of representativeness of the set of photos.
2. How does representational system and enchantment inter-connected in creating the experiential design of science centres?	Photography	The data for each atmospheric quality were organized into an analytical template.
3. What are the design opportunities that will enhance visitor experiences in science centre?	In-depth interview	The key data analysis strategies are topic coding and analytical coding while memoing was an ongoing procedure that ensured design-relevant implications were recorded.

The researcher went around all the Science Centre exhibition spaces in an order defined from main entrance to the final exhibition. Atmospheric quality was photographed to record the ambiance and the order in which galleries were visited. Selected photographs will be used to support and illustrate the findings. This includes: (i) three-dimensional representations, (ii) the lighting of all the selected groups of exhibitions and (iii) the degree of the linearity. Each visit to the Science Centres had an average of six or more exhibition spaces. This photography data recorded depended on the speed with which the researcher moved through each exhibition.

The average duration of one Science Centre visits was 4 to 5 hours. The procedures of photography-based data collection focused on:

i. capturing contextual data of architectural style
ii. general interior atmospherics
iii. space layout and design
iv. individual exhibits and displays

3.7.2 Systematic Procedures of Photography-Based Data Collection

The approach on photographic analysis was divided into three steps:

1. The first step was to capture the exhibition / experiential design of science centres. This includes collecting information so as to ascertain what the science centres were offering. Each photograph taken was identified by a comment stating its context (the scene depicted and the time of shooting). Notes on important aspects of the exhibition includes the researcher's experience and sensory stimuli. This note-taking constituting a supplementary source of information to the visual data.

2. The photos were arranged in order to bring out the major themes around which the experience is organized. The purpose here was to shift from a chronological to a thematic arrangement of the photos.

3. The third stage involved going back to the theory for design-relevant implications. The set of analyzed data i.e. thematic arrangement of the photos were compared with the literature regarding the content specialization of scientific knowledge projected by a science centre. This

stage avoids basing this approach on the photographic analysis alone and to limit the one-dimensional character of the analysis based on the researcher's view alone (so limiting the risks of over interpretation; Spiggle, 1994).

3.8 IN-DEPTH INTERVIEWS

In-depth interview is a research method widely used in design research and social science research. As a primary form of inquiry, it is the use of open, direct, verbal questions to elicit narratives and comments (Miller & Crabtree, 1999). The process is “conversation with purpose” in which the interviewer aims to obtain the perspectives, feelings, and perceptions from the research participants (Holloway, 1997). The researcher identifies a purposefully selected sample of interviewees and talks to the interviewees either one-to-one or in groups to elicit their comments about certain topics of research interest. The interviewees’ opinions form the basis for data analysis. The interview format also makes it possible for the informants to take a perspective on the past or discuss the future (Holloway, 1997).

In-depth interview is chosen as the second data collection method for this research because: (a) Design experiences often take the form of stories to be shared through conversation; (b) As the subjects of inquiry are process based and goal oriented, talking with science centre professionals becomes the most straightforward way to learn about useful information from the research targets; (c) The study is exploratory in nature. It attempts to understand experiences from the informants’ perspectives. The narrative and open nature of in-depth interviews facilitate understanding in an explorative way.

3.8.1 Systematic Procedures of In-Depth Interview Data Collection

The purpose of the in-depth interview study is to understand topics regarding criteria for design success in science centre. Nine science centre professionals were interviewed. An interview began with the researcher's self-introduction and a brief explanation of the research purposes. Interviews lasting 40 to 90 minutes were conducted with participants using semi-structured questions to gather participant opinions and ideas related to the study topic. A general set of questions, or interview guide (Merriam, 1998) was used to establish some structure and direction for the interviews, but the actual question phrasing varied based on the specific capacity of the interviewee. The same interview guide and list of questions was used for all participants.

The questions asked were related to two primary categories regarding exhibition design processes: (1) current practices and (2) visitor accommodations and educational value. Four questions were designed to help interviewees recall examples of design exhibitions and its development processes.

1. What design and development processes are used in the design and implementation of exhibitions at the science centre and why are these particular methods used?

2. What does the science centre hope to address and how do they go about addressing it through the planning and design of exhibitions?

3. What educational roles are the exhibitions at the science centre intended to fulfill and how are these roles considered in the design process?

4. What accommodations for diverse visitor values, interests, motivations, and learning processes are considered in the design of exhibitions at the science centre and how are these accommodations addressed in the design process?

Additional framing questions to explore in this research relate to two areas regarding exhibition design decisions and planning in science centre:

1. Current practices at the science centre
   - What concerns were considered in the design of exhibitions?
   - What does science centre staff hope/plan to achieve through its exhibitions?
   - What issues, realities, and perceptions impact the design of science centre exhibitions?
   - What benefits and drawbacks are evident in designing new exhibitions?

2. Visitor accommodations and experiential value at the science centre
   - How important is the need to accommodate new and different visitors in the exhibition planning process? How is this accommodation reflected and addressed?
   - How is visitor experience addressed in the exhibition design process?
   - What affective learning opportunities do science centre exhibitions intend to provide to their visitors and how are these opportunities supported in the design?
   - What other visitor considerations are important to the exhibition design process and how are they negotiated in the final designs?

The open-ended format allowed participants to share additional information not intentionally sought, but relevant to the study. As true for many qualitative studies, the interviews and data collection process was intended to be organic; at times the wording of questions varied or were rephrased, and participant responses often prompted follow-up questions to suit the context. Additional questions or probes (Merriam, 1998) were also used to follow up, redirect and clarify participant responses. The final interview question allowed participants to share any additional information they felt was pertinent to the study. A sample of interview questions in Appendix III.

All eight interviews were conducted in face-to-face format. One online interview was conducted due to interviewee overseas location. Prior to the beginning of each interview, the participant was given the opportunity to ask questions regarding the research. The interviews were digitally audio-recorded and/or interview notes were made once the researcher began asking questions specific to the study. The interview recordings were later transcribed for documentation and memoing were detailed for further analysis. The interview process used in this study was iterative and inclusion of additional participants stopped when a point of saturation (Merriam, 1998) was met. As described by Lincoln and Guba (1985), a level of redundancy was reached when no new information (was) forthcoming from sampled units. A level of redundancy in this study was identified when information being collected from the interviews continued to repeat and further suggestions for additional interviewees were no longer provided.

3.8.2 Research Participants

The sampling strategy used for this study is a combination of criterion sampling and chain-referral sampling. “Criterion sampling” means research participants are selected based on meeting predetermined criteria which are decided according to the need of the research study (Miles & Hubermnan, 1994; Kuzel, 1999; and Patton, 2002). "Chain-referral sampling" (also known as "snowball sampling") means identifying eases of interest from research participants who know what eases are information-rich. The researcher gets referrals from research participants who recommend others that can give useful information because they have had similar experiences (Miles & Huberman, 1994; Holloway, 1997; and Kuzel, 1999). For the in-depth interview in this research, the criterion for selecting research participants was stated as: "Science centre professionals in the field of administration, curatorial, education, exhibition design and its related field". The research target of this study represented a range of science centre professionals who provided a variety of perspectives regarding design, both as related to the preliminary design and implementation process, as well as in direct contact with visitors as they interact with museum exhibits.

A list of science centres around Asia pacific which has the potential to be case studies, was shortlisted following the preliminary enquiries held during the ASPAC 2013 Conference. Nine science centre professionals in the Asia Pacific region were contacted for the recruitment of suitable research participants. The researcher gets referrals from research participants who recommend others that can give useful information. The implication for interview participants 'not within the case study, i.e. East vs. West has broadened the understanding on global science centre engagement and experiential design. Refer the list of participants' backgrounds and their credibility in Appendix IV. Consent to conduct this study was obtained before beginning the individual interview process. Prior to contacting the individual participants, the researcher emailed each potential interview participant to provide a general overview of the study. The researcher contacted each potential interview participant via email at least one month before to confirm his/her willingness to participate and to schedule an interview session. Refer sample email in Appendix V. Once a participant confirmed willingness to participate in the study and suggested possible interview dates and times, the researcher followed up with a confirmation. Prior to the interview, each participant was provided with a digital copy of the guiding interview questions. Overall the sequencing of the initial participants was determined by the credibility of the interviewees. Selection of interviewee was based on chain-referral sampling based on recommendation by the respondent. All respondents are highly experienced and involved in the field.

Introductory letter requesting to conduct an interview was sent to the respective science centres. Four science centre replied with the exception of Guangdong Science Centre. An additional two interviews request were arranged with the curator and exhibition designer of the Powerhouse Museum in Sydney. The subsequent contact with Science Centre Singapore was follow-up by an interview with Exhibition Director of Science Centre Singapore. This continued with a series of interviews at other case studies science centres. During an initial contact with Questacon, Director of Science and Learning assisted in identifying two interview participants. The researcher later interviewed Head of Concepts and Education at QTLC and Design and Online Services Manager. Another interview with the curator and exhibition designer of The Powerhouse Museum was conducted in Sydney. The Principal Curator for Physical Sciences & IT assisted and arranged an interview with the Exhibition Designer. On another occasion, the Mind Museum Curator agreed for an interview.

Network sampling (Merriam, 1998) was utilized to identify additional participants. Several interviewees recommended other areas/roles who could potentially offer additional perspective and insight into the exhibition design process. Based on these recommendations, three additional interview participants were identified, bringing the total number of interviewees to nine. A written interview was arranged upon receiving a replied email from Director of Heureka, the Finnish Science Centre. Subsequently Executive Director of Experimentarium Denmark, agreed for an interview during his visit to Petrosains at KLCC. As a final point, a concluding interview was arranged with the Director Creative Design at Team Aranda Sdn Bhd. who was then the Associate Director at Petrosains Malaysia between 1998-2007.

3.9 DATA ANALYSIS PROCEDURES FOR PHOTOGRAPHY

The photographs were analyzed with grid data analysis approaches for design-relevant implications. A thematic analysis was performed to understand the tools for enchantment of the science centre experience. An analytical strategy based on adopted grid for analyzing cognitive implications of the exhibits' design in a science centre was used (Koulaidis et.al., 2002). The theoretical notions of classification (Bernstein,1996), formality (Halliday, 1996) and framing (Bernstein, 1996) was used to describe the access that the exhibits allow a visitor to the knowledge implication and to analyze data for identifying the multiplicity of representational modes.

3.9.1 Enumerative Analysis

Enumerative analysis is the counting element in qualitative analysis. While the process involves obtaining frequencies or quantities from the data, it must be emphasized that the basic purpose of enumerative analysis is to provide a numerical overview of particular aspects of the data, but not for statistical inferences (Grbich, 2007). For the enumerative analysis in this photographic medium study, the purposes are to (1) identify the classifications, formality and framing of three dimensional-representation; (2) identify the formality and framing of lighting and (3) identify the framing of degree of linearity at all the selected exhibitions at the science centres. All these purposes are achieved by counting the frequencies observed. The results are reported in chapter 4.

3.9.2 Analytical Template

An analytical template was developed to prepare data for in-depth analysis. Each case on the types of concerns for the representational modes was preliminarily analyzed by organizing information into the analytical template with four components as shown in Table 3.3.

Table 3.3
Analytical template

Component	Definition
Representational system	Types of concerns for the representational modes selected in this study: i. three-dimensional representations ii. lighting iii. degree of linearity
Classification	This determines the epistemological relationship between knowledge categories (Bernstein, 1996). The categories examined are the specialized 'techno-scientific knowledge' and the 'everyday knowledge'. For example, the exhibits promote strong classification when they portray techno-scientific knowledge as epistemologically distinct from the everyday knowledge. On the contrary, they promote weak classification when they present these two types of knowledge as mixed in a blurred way.
Formality	The degree of abstraction, elaboration and specialization of the expressive codes employed. Low formality corresponds to codes resembling close to the realistic appearances of things. High formality corresponds to codes in terms of abstractions and deeper regularities (Halliday, 1996, & Kress and van Leeuwen, 1996).
Framing	The locus of control over the communication established by the exhibits (Bernstein, 1996). Framing regulates the social relations within the context of a science centre. Strong framing means that the visitor is deprived of any control over the ways he/she will interact with the exhibits while weak framing means that the visitor has available a wide range of options for accessing the science centre. The notion of framing referring to the dimensions of: i. The power (hierarchical) relationships implied between the exhibits and the visitor. ii. The control of the conditions for the visitors' involvement with each individual exhibit. iii. The control of the conditions for the visitors' accessing the various parts of a science centre (degree of linearity of a science centre).

The photographic data of all the science centres under study were organised according to the analytical template before thematic analysis was performed to understand the representational modes in physical context of the science centres. Data from analytical template of the photographic medium were systematically coded to identify:

v. The types of epistemological relationship between knowledge categories.
vi. The degree of abstraction, elaboration and specialization.
vii. The locus of control over the communication established by the exhibits.
viii. The social relations within the context of a science centre.

Photographic analysis explains the second research question which is the conceptual understandings on the interconnection between science centre representational systems and the tools for enchantment of the science centre experience.

3.9.3 Analytical Grid of Analysis

The photographic data was preliminarily analyzed by organizing information into the analytical grid of analysis. The way the notions of classification, formality and framing become operational for each of the aforementioned modes identified. Based on the limitation of time and budget factor, the analysis on two-dimensional, sound and graphic text were excluded. Only functions on three dimensional representational systems, lighting and degree of linearity were analyzed. This research analyzed only the mentioned representational modes, being though fully aware of the need to extend the analyses so as to take into consideration more representational modes in them.

3.10 DATA ANALYSIS PROCEDURES FOR IN-DEPTH INTERVIEW

Analysis of data throughout the course of this study was an "iterative and generative process; the themes emerge from the interview data and they give the data shape and form” (Lawrence-Lightfoot, 1997). While collecting data on-site at the case studies science centres, decisions and generation of ideas related to the problem were ongoing by the researcher. Although some connections and relationships in the data began surfacing during the data collection process, formal analysis of the data commenced with verbatim transcription of the interview recordings, review of researcher notes, and compilation of document notes. Open coding and selective/focused coding methods were used to analyze, deconstruct and reconstruct the data to identify themes (Emerson, Fretz, & Shaw, 1995; Glaser & Strauss, 1990; Strauss & Corbin, 1998).

3.10.1 Interview Transcription, Research Notes and Memoing

Recurring ideas and concepts began to surface during the transcription process and the research started to take on the early stages of a tangible form. Of the eight on-site interviews, all were transcribed to gain an understanding and appreciation for the process. Notes were taken during each interview and detailed on the memoing to reflect the interview process and general topics addressed. The notes enhanced the researcher recollection of non-spoken details or tone conveyed during interviews. The memoing contributed to determining ongoing changes and modifications in the interview process. Following completion of all interviews and transcriptions, the interview notes and transcribed audio memoing were reviewed to help inform the coding process.

3.10.2 Coding

In reviewing the interview transcriptions, recurring ideas, words, and themes were formulated. A hybrid of open coding and selective or focused coding (Emerson, Fretz, & Shaw, 1995) was used to review the interview transcripts line-by-line, marking passages recognized as containing ideas or themes deemed either of general interest to the study or meaningful to the research questions. These excerpts or passages were coded and organized into categories. Then connecting threads or convergent patterns among the categories were interpreted to identify themes (Lawrence-Lightfoot, 1997; and Seidman, 2006). As described by Strauss and Corbin (1998), this process felt like working on a puzzle, in which the researcher had to get organized, sort the pieces by colour…and build a picture by putting the individual pieces back together. Although some aspects of the coding process remained consistent across all interviews, some of the researcher methods and approaches continually evolved with each step and subsequent interview. After an initial read-through of the interview transcripts with a loose open coding approach to gain a sense of broad and repeated ideas, the researcher devised a focused or selective coding scheme based on the interview questions the researcher had asked. This was realized as not an efficient or effective approach to correlate interview data with the research, so the researcher revised the coding scheme into 5 topics/codes related directly with the research questions.

These codes were used in the initial manual coding of all the interview transcripts. While reviewing a printed copy of each transcript, the researcher highlighted text relevant and marked these highlighted passages with a code corresponding to the topics and ideas relative to the research questions. In some cases multiple codes were identified next to a particular passage. The researcher also noted key words and ideas related to each passage in the margins to begin generating a list of recurring ideas across interviews. After coding the first two interviews, a colour-coded highlighting process was implement to more readily identify which passages related to which question areas. This colour coding was particularly helpful to identify passages which related to multiple question areas. For the following interviews, the transcript was manually coded and then followed up immediately by copying the marked passages from an electronic version of the transcript into a Microsoft Word table.

The first column was populated with primary ideas or evolving themes evident in a participant's responses, which consisted of abbreviated versions of the ideas noted in the margins during the manual coding phase. Using the concepts noted in the third column for each question, another table was generated compiling the ideas from all the interviews. This process reflects implementation of axial coding, to "fit the pieces of the data puzzle together" (Strauss & Corbin, 1998). By looking at this set of information, a list of key ideas was generated and overlapping concepts emerging across the interviews. Coding and analysis of the data resulted in identification of five main themes which surfaced on multiple layers related to the exhibition.

Once completed, the coded data was represented in a table form together with verbatim quotes. Along with each quotation, the corresponding participant name was included to indicate where the passage originated. During this process notes were made, in order to begin generating more general emerging themes. Although still rough and evolving, the data began to become more conceptually linked during this axial phase of sorting and coding interview data. In reviewing and synthesizing the quotations, twenty-one themes were concluded upon cutting across all data interview. Next, the specific interview passages that was extracted were sorted and cross-referenced into these five themes. All the passages were printed out, as related to each of the five topics previously determined - each topic printed on a different coloured paper - and cut apart all the quotes into individual slips of paper. The quotes were read through and sorted into separate piles corresponding to the five themes. In addition to the five primary piles, secondary piles were also created to place passages which represented ideas bridging between each of the main themes, and had a pile for passages that did not fit cleanly into any one of the designated theme.

Then, each pile of quotes related to each of the separate themes were scan through and sorted the quotes into relevant subthemes or reoccurring topics. These five themes and corresponding twenty-one subthemes are addressed in detail in the findings of this study. The data analysis and coding process for this study was iterative and ongoing, throughout the writing and final review of the findings. During the writing phase, some quotations or passages were moved, if better suited to substantiate a different theme. In some instances, a quotation was considered redundant or unnecessary and removed completely from the data to support a particular theme. In other instances, additional quotes were sought out from the original data to help provide evidence for a specific theme or subtheme. In order to help ensure validity, "member checks" (Merriam, 1998) were conducted whenever possible. A follow-up questionnaire of this study, was sent to interview participants to provide the opportunity to verify their ideas and were conveyed relative to the themes generated. Any feedback received from participants was reviewed and addressed accordingly as it fit within the context of the study.

3.11 OVERVIEW OF RESEARCH PROCESSES

This research followed a basic interpretive qualitative research approach. The reason for conducting this study was "simply to seek, to discover and understand a phenomenon, process, or perspectives and worldviews of the people involved" (Merriam, 1998). As stated by Merriam (1998), "A case study design is employed to gain an in-depth understanding of the situation and meaning for those involved. The interest is in process rather than outcomes, in context rather than a specific variable, in discovery rather than confirmation". Thematic analysis was performed to understand the representational modes in physical context of the science centres. Thematic analysis is a widely used data analysis approach in qualitative research studies, especially those in the field of social science. It is the process of identifying themes or concepts through searching the data for related categories with similar meaning.

The research questions show the flow of inquiry from discovery to explanation and then to implications. The research process starts with identifying the tools for enchantment of message in the science centre experience. Next, the research classifies the sources in atmospherics and the exhibition environment that generate visitor responses. This is identified as the representational modes in the exhibitions. Building on insights from answering the first two research questions, the research then proceeds towards categorizing design opportunities that will improve visitor experiences in the physical context. This flow of inquiry indicates that this research is exploratory in nature, in the sense that it aims at discovery of conceptual insights and practical implications. Due to time and access constraints of conducting in-depth case study analyses of multiple science centres, this study is limited to interpretation and analysis of the data gathered at selected case study science centres. Rather than studying the visitor reaction to technology used in exhibitions, this study focused primarily on the decision-making process of designing science centre from the perspective of professionals working in these cultural institutions. This study intended to explore the perspectives and decisions of curatorial and managerial objectives in a "bounded system" (Merriam, 1998, 2002) as related to science centre exhibitions, and their implications for interactivity and experiential learning in their museum environment. The research stages are illustrated in Figure 3.1. Research Process.

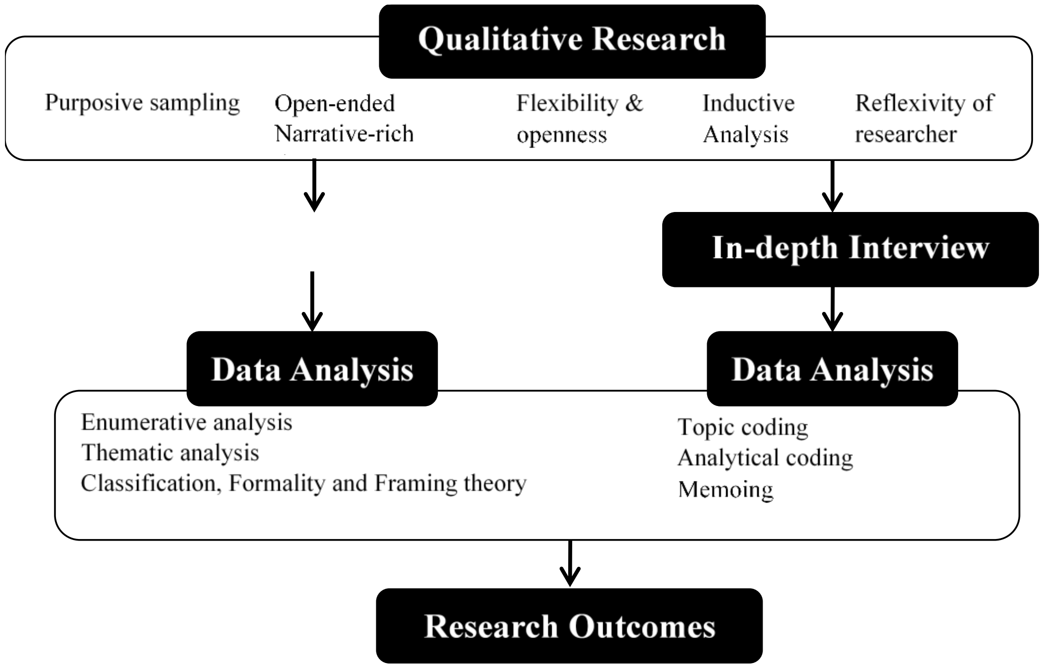


Figure 3.1 Research Process

The processes of this research started with a review of literature in four subject areas: Learning Theory, Visitor experiences, Experience design, and Atmospherics and the Exhibition environment. Next, informal interviews were conducted with science centre professionals. There are five key research stages: (1) Development of research questions (2) Research design (3) Data collection (4) Data analysis (5) Research Outcomes.

3.12 ASSUMPTIONS

The qualitative methodology of this research, by its nature, required interpretation on the part of the researcher. Data was gathered through interviews with centre administrators and staff (educators, curators, designers). It is important to mention that given the role as both researcher and interviewer, all decisions, procedures, and analysis in this study were impacted by the lens through which the researcher view the world and all that happens within it. The researcher past experience - educationally, socio-culturally, and particularly in terms of own perspectives related to museum environments - impact the overall approach to this study, as well as interpretations of the data and understanding of the findings. Hence it is essential to stay self-aware and self-critical throughout all the processes of the research. The processes of reflecting, exploring, sifting and elucidating the nature of the phenomenon under investigation (Douglas & Moustakas, 1985) is constantly goes through. For the purpose of maintaining reflexivity, qualitative research experts recommend the use of documentation or logs to record insights during the research process and reflect on possible bias (Miles & Huberman, 2002). The principle of reflexivity is applied through several measures that facilitate reflection and increase credibility. Other than being self-critical and keeping logs both digitally and in the form of research notebooks, the researcher also has taken other measures to minimize bias or distortion. Biases are also possible for any researcher acting as an interviewer. Precautions to minimize bias in the research process were taken by: (1) requesting a few interview participants from a series of case studies science centre staff; (2) utilizing open-ended questions and follow-up questions to assure accuracy of participant responses; and (3) using comprehensive coding and analysis techniques to interpret the data.

3.13 SUMMARY

The qualitative methodology of this study provided a rich set of data collected through photographic analysis and in-depth interviews from a case study of selected science centres. Throughout the study - while planning, selecting participants, gathering data, organizing topics and searching for themes - the process was iterative and generative in nature. A total of six renowned science centres were purposefully selected as the case study because of its size, location and unique design efforts. A thematic analysis was performed to understand the tools for enchantment of the science centre experience. For the purpose of understanding science centre representational systems, data from analytical template were coded to identify (1) the types of epistemological relationship between knowledge categories; (2) the degree of abstraction, elaboration and specialization; (3) the locus of control over the communication established by the exhibits and (4) the social relations within the context of a science centre. A total of nine semi-structured interviews were also conducted as part of the study. The interview questions were formulated based on the research questions and additional framing questions to situate the context of the research in terms of (1) exhibition design practices and implementation and (2) visitor accommodations. A wide range of public documents from the science centres, as well as researcher memoing and notes from the interview process, were used to supplement the data collected from participant interviews. This research focuses on a multiple case science centres - providing a wider, in-depth and detailed look at the myriad of conceptual and logistical which impact experiential design in science centre.

CHAPTER 4

RESULTS, ANALYSIS AND FINDINGS

4.1 INTRODUCTION

This chapter presents and discusses research results, analysis and findings underlying the structuring of the experience in science centres. This is elaborated in five sections. The first section begins with the findings through the photographic medium**.** This includes understanding the structural dimensions of science centre offer and discuss the characters that structured the experiences offered by these science centres. The second section discuss results and findings on the representational systems from the photo medium study analysis. The three-dimensional representations, lighting and degree of linearity are explained in three parts: classification, formality and framing. The third section discuss findings from the in-depth interview study. The curatorial and managerial perspectives on design opportunities that enhance visitor experiences are discussed in five themes. The fourth section presents findings and discussions underlying the interpretation of the experience offered by science centre. This is reviewed in light of the three research objectives. The fifth section concluded the research findings. It examines the outcomes of this research in relation to the current knowledge between visitors and the exhibition environment of science centre.

4.2 THE ENCHANTMENT OF MESSAGE IN SCIENCE CENTRE

The proliferation of science centre seems to have blurred the old distinction between traditional museum activities and leisure activities. To better understand the reality, the broad principles that guide the structuring of these experience is identified through the photographic medium which captures contextual data by direct observation. The collection of contextual data, or "local groundedness" refer to data that were collected in close proximity to a specific situation.

4.2.1 The Tools for Enchantment of Message

The effort for attraction in science communication can be identified as the characters that structured the science centre experience. This is related to the first research question of this study:

'What are the tools for enchantment of message in the science centre experience?'

The photographic analysis denotes a wide range of the physical environment in which visitor experience occurs namely spatialization. Findings through the definition of the architecture, decoration (light and colour) and the general atmosphere is consistent with Joy et al. (2003) claim that these environmental elements and their intensity are critical because they directly affect the mood of the visitors. The photographic analysis findings show that science centres are based on logic of knowledge culture and recreation. These centres use "fun" as the main vector of the experience. "Fun" according to Blythe and Hassenzahl (2003) is a key concept in enjoyable experiences. It is a distraction that enables people to become temporarily oblivious of their problems and self-definition. The distraction fulfils an underlying psychological need. It is mobilized for an educational purpose, which is accompanied by the more traditional task of knowledge transfer. This mission is parallel to the classical model of the museum in charge of acquiring, preserving, studying and exhibiting items for the purposes of learning, education and enjoyment as underline by the International Council of Museums (2007). However, unlike traditional museums, these science centres seek to immerse visitors in a stimulating environment to enable meaningful learning. The exhibitions cautiously define the scientific content and the mediation tools through playing on emotions and sensations of their visitors simultaneously. Findings indicate science centre as a "learning-oriented entertainment experience" consistent with what was suggested by Falk and Dierking (1992), where it seek to enhance the visitor experience through an experiential redefinition of what museum offers. The next section discusses the results and findings through the photographic medium**.** This includes analyzing the structural dimensions of science centre offer and discuss the characters that structured the experiences offered by these science centres namely - thematization, spatialization, and scenarization of the experience.

i. Thematization

Thematization, defined by Fırat and Ulusoy (2009) as "…the patterning of space, activity or event to symbolize experiences and/or senses from a special or a specific past, present, or future place, activity or event as currently imagined" is a strategy that have emerged and flourished all around the world. According to Sherry et al. (2007), it is a culture based strategy so powerful in contemporary society that one has more powerful and significant experiences in "themed environments" than in other environments. Good experience design uses all physical context elements to support an underlying vision, metaphor, or theme as suggested by Pullman and Gross (2004). Conceptualizing and operationalizing experience is important to better comprehend the new perspectives regarding strategies; their impact on behaviour and recent practices. Findings indicate these science centres offer various themes in delivering the experience. Examples includes Atom, Earth, Life, Universe and Technology Exhibition at the Mind Museum. Each exhibition gallery is identified through these physical context elements as metaphor. The various themes conceptualize the message as shown in Figure 4.1 and 4.2. In this context, engagement is effected by proposing space to visitors so they can relate in achieving the experience. The exhibitions experience is inseparably bound to the proposal of a theme, a symbolic dressing-up of the context that gives meaning to the one's act as suggested by Caru and Cova (2006).

Figure 4.1: Thematization at Atom Exhibition of The Mind Museum

Figure 4.2: Thematization at Science Exploration of Macao Science Centre

ii. Spatialization

Besides thematizing the experience, these science centres activate another enchantment lever: spatialization as shown in figure 4.3. The focus is on the physical environment in which the visitor experience occurs, especially through the definition of the architecture, decoration (light, colour, etc.) and the general atmosphere of the place. Visitors are to be immersed via work on the physical environment of the exhibition and on the pathways through the exhibition space as shown in figure 4.4. In some parts of the exhibitions, spatialization involves implementing hyperreal environments as shown in figure 4.5. These are reconstructed environments that are more artificial than authentic, combining things real and imaginary as suggested by Rojek (1993).

Figure 4.3: Spatialization at Perception & Thinking Exhibition of Guangdong Science Centre

Figure 4.4: Spatialization at Questacon Foyer

iii. Scenarization

Definition of the thematization and spatialization of the exhibitions are bound up with considerations on scenography. Whereas museography relates to the conservation, preservation and presentation of works, scenography is about staging them attractively and consonantly with the space, while making the scientific purpose explicit. For example, the chosen scenographic techniques are employed to define the intrigue and to help in creating a scenario as shown in figure 4.6.

Figure 4.5: Spatialization at Universe Exhibition Gallery of The Mind Museum

Figure 4.6: Scenarization at Experiments & Discovery Hall of Guangdong Science Centre

The more straightforward and better known the storyline, the more visitors will be able to make it their own. The purpose of this scenarization of the theme is to provide reference points for visitors, to allow them to create meaning and to access the content of experience more easily as defined by Hollenbeck et al. (2008). The findings are generally applicable in all the case study science centres (Refer Appendix VI). The ability of these science centres to thematize, spatialize, and scenarize their offers determines the degree of enchantment of the experience. Subsequently, the research findings discuss four characters that structured the experiences offered by these science centres namely spectacular, immersive, ritualized and merchandise offer.

4.2.2 Spectacularization of the Cultural Experience

The first dimension that structured the experience proposed by these science centres relates to its spectacular character. Spectacularization of the cultural experience have emerged from this analysis. It is part of the out-of-the-ordinary character that the visitor experience takes on to attract consumers as suggested by Caru and Cova (2005). In the cultural sector, theatricization of the visitor offer is intrinsically present because of a substantial experiential content. In the case of these science centres, spectacularization takes on two forms: the architecture and the hyperreal character of the offer. The spectacular character of the site is crystallized in its external envelope through the grandiose and ultra-modern architecture. For example, before one even get into the complex, visitors are set upon the masterful character of the building's architecture at Guangdong Science Centre as shown in figure 4.7. It seems possible to interpret the overall architecture. The building’s appearance resembles the five petal Kapok flower which is the city emblem of Guangzhou. The main building is balance with a man-made lake for water-themed exhibitions and an outdoor science square.

Another example is Macao Science Centre building's architecture which has a playful volume consisting of a rhomboid, a dome and a tilted cone as shown in figure 4.8. Designed to articulate the functional program, the centre exploit its waterfront setting and a landmark of Macao. The choice made by the architects clearly corresponds to one of the devices most often used in the race among museums to be out-of-the-ordinary (Frey, 1998). It seems that the building's architecture is as much a part of the offer as the works or objects that it houses. These science centres become a highly symbolic architectural vessel. In the architecture of Guangdong Science Centre and Macao Science Centre, the outer envelope materializes the visitor experience and becomes a source of value, making the centres attractive and contributing to its reputation.

Figure 4.7: Spectacularization in Guangdong Science Centre building's architecture

Figure 4.8: Spectacularization in Macao Science Centre building's architecture

These science centre buildings become flagstaff reflecting the overall offer that they contain. However, spectacularization is also built into all of the amenities defined internally as showcases for the objects on exhibit. The findings as shown in figure 4.9 indicate while for some exhibitions the architecture can take a back seat, providing a neutral technical instrument that can be adapted to whatever scenography may be required; in other exhibitions, on the contrary, the spaces, lighting, colours and materials dictate how the works are presented.

A marked tendency arises too in the arrangement of the exhibition areas or the visitor paths around the science centre. The challenge for the designers is to recreate the real world, to reconstruct the true through the false - the presentation devices and decorative devices look truer than life. Moreover, there is a juxtaposition of varied dimensions, of different scales of space and time as shown in figure 4.10.

Figure 4.9: Main atrium at Guangdong Science Centre

Figure 4.10: Central space at Questacon

4.2.3 The Immersive Character of the Experience

The second dimension that structured the experience proposed by these science centres relate to its immersive character. This type of mediatization has the peculiarity of no longer placing visitors at a remove from the representation but of plunging them into the heart of it so that they directly feel what it is all about, sometimes even making the experience itself what it is all about (Joy et al., 2003). This characteristic can be presented on two levels. The first level of immersion can be illustrated by an extremely visible scenography designed to plunge visitors into simulated reality and to shape their awareness of their immediate immersion (Addis et al., 2007). In the case of Macao Science Centre, the architects and designers use a number of arrangements to place visitors at the heart of the experience, such as circulation, size and lighting as shown in figure 4.11. This device is a good illustration of the idea of immersion as “a thematised and secure spatial enclave for the consumer" according to Caru and Cova (2006). The second level of immersion corresponds to a number of interactive devices for appropriating the offer and bringing about a gradual interest as shown in Figure 4.12. In this context, engagement is effected by proposing tools or space to visitors so they can connect in achieving the experience.

Figure 4.11: Size and lighting as immersion at Macao Science Centre

Figure 4.12: Interactive devices at Questacon

The degree of visitor participation may vary greatly from one entity to another, ranging from “classical” interaction to genuine participative immersion. The findings indicate science centres has in place numerous conventional (wheels to turn, push button, etc.)

and innovative interactive devices to enable visitors to participate. The task is to get visitors involved through mobilizing variously interactive and immersive mediation tools. This often depending on the level of technological innovation available as suggested by Anderson (2004).

4.2.4 The Ritualized Character of Visitor Experience

The third dimension that structured the experience proposed by the science centre relates to its ritualized character. The social dimension of the experience is also carefully designed in these science centres particularly through the proposal of common rituals for visitors. This idea of ritual is to be understood as (i) a type of expressive, (ii) symbolic activity constructed of multiple behaviours, (iii) occur in a fixed, episodic sequence, and (iv) repeated over time. For example, the central ritual of the Science Centre Singapore is the Fire Tornado Demonstration as shown in figure 4.13.

Figure 4.13: Fire Tornado Demonstration at Science Centre Singapore

The site designers propose a scenarize sequence around the show that is limited in time and space. Ritual behaviour is dramatically scripted and acted out and is performed with formality, seriousness, and inner intensity as suggested by Rook (1985). The show area becomes a place of communion, with the fire tornado in the role of icons and the science communicator as guides, initiating and accompanying the visitors in the ritual. The show is proposed at set times and so takes on a repetitive and standardized character that is peculiar to ritualized actions. Lastly, the ritual is engaged in collectively, thus allowing visitors to live a form of communion, to share emotions through this collective experience as suggested by Cova (1997).

4.2.5 The Merchandizing of Experience

The fourth dimension that structured the experience proposed by these science centres relate to its merchandizing character. The science centres use this character to package its merchandise offer, by making souvenirs available to visitors as products capable of materializing and continuing this relation. Frequentation of the science centre shop is an illustration whereby it is attracting visitors during exit time, when visitors are looking to extend their experience by purchasing miscellaneous souvenirs (from highly educational ones such as specialist books, to fun ones such as soft toys). Moreover, the creation of stores, restaurants, theatres or reception rooms, auditoriums or children's areas may cater for visitors' eagerness to multiply the experiences at the site. In this perspective, the facilities become a real medium for the cultural experience. The experiential dimension of peripheral services is now thought through from the outset of the project to enhance the site. This tendency is reflected by the multiplication of commercial spaces, with themes adapted to the zones where they are based. The souvenirs ("memorabilia mix") become an essential element to complement, strengthen, and extend in time the staging of re-enchantment of the experience as suggested by Pine and Gilmore (1999). This dimension is discussed in museology. While museums have long been thought of as not being subject to market forces, it seems they must now come to grips with a more commercial logic (extending spaces, developing shops, restaurants, having their own brands for some products, etc.) so as to draw in a growing number of visitors (Werner, 2005).

4.3 THE REPRESENTATIONAL MODES IN SCIENCE CENTRE

This next section examines through the photographic medium which captures contextual data by direct observation, leads to familiarizing the representational modes in communicating the science centre intent. This is in relation to answer the second research question of this study:

'How is the interconnection between its representational systems and enchantment of the science centre experience applied?'

This finding provides the logic underlying the structuring of the experience offered by cultural institutions. For each dimension of the visit experience, the content and resources employed by its designers were analyzed through direct observation. The photographic data of all the case study science centres were organised according to the analytical template before thematic analysis was performed to understand the representational modes in physical context of the science centres. Data from analytical template of the photographic medium were systematically coded to identify:

ix. The types of epistemological relationship between knowledge categories.
x. The degree of abstraction, elaboration and specialization.
xi. The locus of control over the communication established by the exhibits.
xii. The social relations within the context of a science centre.

Selected photographs are used to support and illustrate the line of argument. This includes: (i) three-dimensional representations, (ii) the lighting of all the selected groups of exhibitions and (iii) the degree of the linearity.

All the aforementioned representational modes were analysed in terms of their contribution to the level of content specialization (classification), codes' elaboration (formality), and their interpersonal/affective function (framing). Each case on the types of concerns for the representational modes was preliminarily analyzed by organizing information into the analytical template. One of the sample case study, results and analysis of National Science Museum Korea is elaborated. Next, the findings on the overall results will lead to draw on conclusions of the pedagogical functioning from the six-selected science centres with respect to the issue of promoting the investigative learning of science. The summary of the analytical template is available in Appendix VII for all six-selected science centres. The overall results are shown in Appendix VIII.

4.3.1 Results and analysis of National Science Museum Korea

A series of site analysis and observation of case study National Science Museum Korea suggests a variety of common reference to the every-day experiential world of the visitors and this is mainly done by providing examples of the way the specialized scientific knowledge finds applications that change our everyday lives. Refer Table 4.1.

i. Classification modulation by the three-dimensional representations

a. Form

The three-dimensional representations have six realistic representations (weak classifications) and four conventional representations or hybrid (strong classifications). The representations exhibit more reality according to human optical perception. Conventional representations are constructed according to the techno-scientific conventions and are usually graphs, maps, flow-charts, molecular structures and diagrams. Hybrid representations are usually conventional representations with added on realistic features. The observation suggests that there are a mix of strong and weak classifications in three exhibitions.

b. Function

The three-dimensional representations have six metaphorical representations (weak classifications) that symbolise meanings over what they literally represent. These weak classifications highlight that there are many references to the every-day experiential world of the visitors. This is done by providing examples of the way the specialized techno-scientific knowledge finds applications that change the everyday lives. The classificational, analytical and narrative function which represents strong classifications is less (shown in four exhibitions).

Classificational representations are those that exhibit type of relationships between the represented entities or to put it differently, a taxonomy. Analytical representations are those that focus on the relations between the ‘objects’ of representation in terms of a part-whole structure. Narrative representations are those that represent 'unfolding actions and events, processes of change and transitory spatial arrangements.

Findings indicate that science centre portray less techno-scientific knowledge as epistemologically distinct from the everyday knowledge, for the visitors to grasp few at a time essentials of the techno-scientific content. There are three exhibitions which represent a mix of strong and weak classifications to develop an investigative and independent approach towards science learning, without draining visitors with the complexities of the specialized and abstract techno-scientific conventional expressive systems.

Table 4.1
National Science Museum Korea Classification modulation by the three-dimensional representations

Representational characteristics	Strong classification	Weak classification
Form	Conventional representation or hybrid *Natural History / History of Science / Industrial Technology/Space Exploratorium*	Realistic representation *Natural History / History of Science / Basic Science/ Industrial Technology/ Children Playground / Science Alive Center*
Function	Classificational, Analytical, Narrative *Natural History / History of Science / Industrial Technology/Space Exploratorium*	Metaphorical *Natural History / History of Science / Basic Science / Industrial Technology/ Children Playground / Science Alive Center*

ii. Formality modulation by the three-dimensional representations

Formality are used to describe the access that the exhibits allow to a visitor to the interior of the specialized techno-scientific knowledge. The three-dimensional representations contribute to the level of the exhibits' abstraction and hence to the level of their formality. This is reinforced in three-dimensional representations by the colour differentiation, partial or full of the object represented and texture of the representations. Refer Table 4.2.

a. Colour differentiation

The three-dimensional representations promote low formality in its colour differentiation. In particular, five exhibitions have three or more colours. The expressive codes of low formality are close to the realistic appearances of things, the attempt is to link the specialized knowledge with the everyday experiential world in terms of providing explanations and the vernacular and realistic codes employed. The high formality which represents deeper 'essence' of what it depicts is shown in two exhibitions.

b. Part of the object represented

The three-dimensional representations promote low formality. The observation suggests the exhibition have mostly full representation (six). There are one which is categorized as partial representation.

c. Texture

The three-dimensional representations promote low formality in its texture. The representations have mostly relief surface (six). There are one which is categorized as flat surface which represent high formality.

Table 4.2
National Science Museum Korea Formality modulation by the three-dimensional representations

Representational characteristics	**High formality**	**Low formality**
Colour differentiation	One or two colours *Basic Science/ Industrial Technology*	Three or more colours *Natural History / History of Science / Children Playground / Space Exploratorium / Children Playground/ Science Alive Center*
Part of the object represented	Partial representation *Space Exploratorium*	Full representation *Natural History / History of Science / Basic Science / Industrial Technology / Children Playground / Science Alive Center*
Texture	Flat surface *Space Exploratorium*	Relief surface *Natural History / History of Science / Basic Science / Industrial Technology / Children Playground / Science Alive Center*

iii. Framing modulation by the three-dimensional representations

The findings of strong and weak framing are reinforced by the power relationships and visitors' involvement of the three-dimensional representations. Refer Table 4.3.

a. Power relationships

Three-dimensional representations tend to contribute to the regulation of the interpersonal/affective relationships between the exhibits and the visitors. The element that contributes to the formulation of the power (hierarchical) relationships between the exhibits and the visitors is the exhibits' size and the vertical angle of view. The human-like size exhibits which can be viewed at an eye-level and which can be also manipulated by a visitor is the majority (seven exhibition). This tends to create a feeling of familiarity and call for involvement and promotes weak framing. There are four exhibitions with a three-dimensional representation that is large in size, can be viewed from a high and oblique angle and which cannot be touched, tends to create a feeling of diminishment and alienation of the visitor and hence promotes strong framing. There are four exhibitions with a mixture of small and large exhibits.

b. Visitors' involvement

There are five exhibitions where the three-dimensional representations promote weak framing in its visitors' involvement. The representations are mostly where visitor can manipulate the exhibit. There are four which is categorized as visitor can only see the exhibit. There are one exhibitions which represent a mix of strong and weak framing.

Table 4.3
National Science Museum Korea Framing modulation by the three-dimensional representations

Representational characteristics	**Strong framing**	**Weak framing**
3. Power relationships	Viewed from below / Large size *Natural History / Basic Science/ Children Playground / Science Alive Center*	Viewed at eye-level or from above / Human like size or less *Natural History / History of Science / Basic Science / Industrial Technology / Space Exploratorium / Children Playground/ Science Alive Center*
4. Visitors' involvement	Side view / Visitor can only see but not manipulate the exhibit *Natural History / History of Science / Basic Science / Science Alive Center*	Frontal view / Visitor can manipulate the exhibit *Basic Science / Industrial Technology / Space Exploratorium / Children Playground/ Science Alive Center*

iv. Formality modulation by lighting

Lighting is an intangible medium but it has an enormous influence on both the perception of physical space and upon the emotional response of those who enter these environments. These issues are addressed with a strong sense of aesthetics, functionality and quality of light to ensure quality visitor experience. Lighting with respect to the surroundings in exhibition spaces suggest a mixture of high and low formality. Refer Table 4.4.

a. Degree of colours realism

The low levels of formality characterize lighting in two out of three cases, namely its degree of colours realism and degree of directionality. In specific, as far as their degree of colours realism is concerned, the lighting has seven exhibitions categorized as realistic colours. There are none which is categorized as unrealistic colours. Whereas with respect to their colour differentiation, six have one or two colours (high formality). Only one is categorized as three or more colours.

b. Degree of directionality

As with respect to their degree of directionality, there are more use of diffuse lighting (five) in the exhibitions. The focused light beam which represents high formality is less (two) in exhibitions. In conclusion, all the previous results converge to a prevailing image according to which, the majority of exhibitions in the cases are characterized by low levels of formality.

The lighting property that plays a crucial role in determining the level of framing is the intensity of illumination of an exhibit in relation to the corresponding intensity of the surrounding exhibits. The observation suggests that the exhibits in the cases is not more intensely illuminated with respect to its surroundings, there is no implied hint to the visitor to draw his/her attention to it and hence the lighting promote weak levels of framing. In specific, six have uniform of lighting everywhere. In this way, lighting reduces the visitor's control and hence leads to strong framing. The observation suggests that, intense lighting appeared less (one exhibition).

Table 4.4
National Science Museum Korea Formality modulation by lighting

Representational characteristics	**High formality**	**Low formality**
Degree of colours realism	Unrealistic colours *None*	Realistic colours *Natural History / History of Science / Basic Science / Industrial Technology / Space Exploratorium / Children Playground/ Science Alive Center*
Degree of directionality	Focused light beams *Space Exploratorium / Science Alive Center*	Diffuse lighting *Natural History / History of Science / Basic Science / Industrial Technology / Children Playground*

v. Framing modulation by lighting

The lighting property that plays a crucial role in determining the level of framing is the intensity of illumination of an exhibit in relation to the corresponding intensity of the surrounding exhibits. The observation suggests that the exhibition in the case study is not more intensely illuminated with respect to its surroundings, there is no implied hint to the visitor to draw his/her attention to it and hence the lighting promote weak levels of framing. Refer Table 4.5. In specific, six have uniform of lighting everywhere. The observation suggests that, intense lighting appeared in one exhibitions.

Table 4.5
National Science Museum Korea Framing modulation by lighting

Lighting Property	Strong framing	Weak framing
Intensity of lighting with respect to the surroundings	More intense lighting with respect to the surroundings *Science Alive Center*	Uniform lighting everywhere *Natural History / History of Science / Basic Science / Industrial Technology / Space Exploratorium / Children Playground/*

vi. Framing modulation by the degree of linearity

The strength of each exhibit' connections to the other exhibits can be estimated by the existence of signs of explicit or implicit (e.g. morphological features such as common colour, background or lighting) reference to other exhibits, the proximity between the exhibits as well as the presence of connective elements such as the numbering of different parts of an exhibit or of a group of exhibits. The prevailing feature of this composition is the degree of its linearity. Findings on degree of linearity with respect to the surroundings in exhibition spaces suggest mostly weak framing. Refer Table 4.6.

a. Reference to the other exhibits

The visitors are allowed to access each exhibit in a rather independent way. Five exhibitions have no reference to the other exhibits. Two exhibitions have explicit or implicit reference (strong framing).

b. Proximity

The degree of linearity promotes slightly weak levels of framing in the proximity of exhibits. Four exhibitions are categorized as distinct from the other exhibits whereas, three have close or overlapping proximity.

c. Connective elements

The degree of linearity also promotes weak levels of framing in terms of connective elements between exhibits. Four exhibitions are categorized as non-existence connective elements. Whereas, three have existence connective elements. In conclusion, weak framing is reinforced by the low levels of linearity with reference to the other exhibits, its proximity and connective elements. The observation suggests that arrangement of physical structure do not impose a linear way of access to the visitors.

Table 4.6
National Science Museum Korea Framing modulation by the degree of linearity

Characteristics related to degree of linearity	**Strong framing**	**Weak framing**
Reference to other exhibits	Explicit or implicit reference *Natural History / History of Science*	No reference *Basic Science / Industrial Technology / Space Exploratorium / Children Playground/ Science Alive Center*
Proximity	Close or overlapping with other exhibits *Natural History / History of Science / Industrial Technology*	Segregated and distinct from the other exhibits *Basic Science /Space Exploratorium / Children Playground/ Science Alive Center*
Connective elements	Existence *Natural History / History of Science / Industrial Technology*	Non-existence *Basic Science /Space Exploratorium / Children Playground/ Science Alive Center*

4.3.2 Findings on Three-Dimensional Representations

A series of site analysis and observation of all the case study science centres suggests a variety of common reference to the every-day experiential world of the visitors and this is mainly done by providing examples of the way the specialized scientific knowledge finds applications that change our everyday lives.

4.3.2.1 Classification Modulation

The content specialization promoted by the three-dimensional representations is determined by:

3. The form

4. The function of each representation

The forms are distinguished into conventional, hybrids and realistic ones. All representations that represent reality in a codified way are considered as conventional. These representations are constructed according to the techno-scientific conventions and are usually graphs, maps, flow-charts, molecular structures and diagrams. Hybrids are usually conventional representations with added on realistic features. Finally, all the representations that exhibit reality according to human optical perception are considered as realistic.

a. Form

The three-dimensional representations promote weak levels of classifications in both its form and function. As it becomes evident from Appendix VIII the representational modes that contribute to the content specialization (classification) analyzed in this studies are the three-dimensional representations. In specific, as far as their form is concerned the three-dimensional representations have more realistic representations (fourty-four out of fourty-nine exhibitions) as shown in Figure 4.14 and Figure 4.15. The representations exhibit reality according to human optical perception.

The conventional representation or hybrid form which represents strong classifications is shown in eighteen out of fourty-nine exhibitions as shown in figure 4.16. Conventional representations are constructed according to the techno-scientific conventions and are usually graphs, maps, flow-charts, molecular structures and diagrams. Hybrid representations as shown in figure 4.17 are usually conventional representations with added on realistic features. The observation suggests that there are a mix of strong and weak classifications in thirteen exhibitions.

Figure 4.14: Representations exhibit reality at Earthquake simulation of Macao Science Centre

Figure 4.15: Representations exhibit reality at Children's Wonderland of Guangdong Science Centre

Figure 4.16: Conventional representation at Robotic Science of Macao Science Centre

Figure 4.17: Hybrid representation at Technology Exhibition of The Mind Museum

b. Function

The three-dimensional representations are more metaphorical (fourty-two out of fourty -nine) as shown in Figure 4.18 and 4.19. Metaphorical representations are those that symbolise meanings over what they literally represent. These weak classifications highlight that there are many references to the every-day experiential world of the visitors. This is done by providing examples of the way the specialized techno-scientific knowledge finds applications that change the everyday lives. Findings indicate science centre as a “learning-oriented entertainment experience” consistent with what was suggested by Moscardo (1999) where an interpretive experience was able to make a visitor "mindful". This mindfulness can be created by interpretive practices that encourage control, interaction, and activity, as well as introducing novelty, pique the visitors' personal interests, and properly orient them to the interpretive subject.

Figure 4.18: Metaphorical at IZ Hero Gallery of Science Centre Singapore

Figure 4.19: Metaphorical at Children Science Playground of National Science Museum Korea

Design is recognised as an integral part of the visitor experience, with potentially more far-reaching implications for structuring the very nature of that experience as suggested by Macdonald (2007). The classificational, analytical and narrative function which represents strong classifications is less (shown in twenty out of fourty-nine exhibitions) as shown in Figure 4.20 and Figure 4.21. Classificational representations are those that exhibit type of relationships between the represented entities or to put it differently, a taxonomy. Analytical representations are those that focus on the relations between the ‘objects’ of representation in terms of a part-whole structure. Narrative representations are those that represent 'unfolding actions and events, processes of change and transitory spatial arrangements' (Kress and van Leeuwen, 1996, p.56).

Figure 4.20: Classificational representations at The Mind Museum

Figure 4.21: Analytical representations at Macao Science Centre

There are thirteen exhibitions which represent a mix of strong and weak classifications to develop an investigative and independent approach towards science learning, without draining visitors with the complexities of the specialized and abstract techno-scientific conventional expressive systems. Findings indicate science centre as a “learning-oriented entertainment experience” consistent with what was suggested by Bitgood (2002) where visitor attentions spans are affected by how much physical and mental effort they have to put in to stay on an exhibit.

4.3.2.2 Formality Modulation

Formality are used to describe the access that the exhibits allow to a visitor to the interior of the specialized techno-scientific knowledge. The three-dimensional representations contribute to the level of the exhibits’ abstraction and hence to the level of their formality. This is reinforced in three-dimensional representations by the colour differentiation, partial or full of the object represented and texture of the representations.

a. Colour differentiation

The three-dimensional representations promote low formality in its colour differentiation. In particular, majority (thirty-seven out of fourty-nine) exhibitions have three or more colours as shown in figure 4.22 and figure 4.23. Findings indicate science centre as a "learning-oriented entertainment experience" consistent with what was suggested by Firat and Dholakia (1998) where the realistic appearances of things imply qualities that invoke the senses. It is a crucial strategy for communicating ideas effectively. The scientific knowledge in these science centres does not prevent it from being expressed in codes of low formality.

Figure 4.22: Multicolour representations at National Science Museum Korea

Figure 4.23: Multicolour representations at Questacon

Such codes acting on a superficial level (high formality) usually pose barriers in the understanding of the relevant subject matter and alienate the effort to grasp the deeper meanings of the scientific concepts as suggested by Martin and Veel (1998). Since the expressive codes of low formality are close to the realistic appearances of things, the attempt is to link the specialized knowledge with the everyday experiential world in terms of providing explanations and the vernacular and realistic codes employed. The high formality which represents deeper ‘essence’ of what it depicts is shown in minority (thirteen out of fourty-nine) exhibitions. Abstraction in this case is accomplished by reduced articulation. Example of one or two colours differentiation is shown in Figure 4.24 and Figure 4.25. There is one exhibition which represent a mix of high and low formality.

Figure 4.24: One colour representations at The Mind Museum

Figure 4.25: Two colours representations at Questacon

b. Part of the object represented

The three-dimensional representations promote low formality. The cases have mostly full representation (fourty-four out of fourty-nine). For example, a globe as shown in Figure 4.26, which is relief, appears as a whole, without built-in elements of the techno-scientific code and characterized by the use of multiplicity of colours is considered a three-dimensional representation of low formality. Another example is the full representation, realistic colour of chocolate bar without any techno-scientific code as shown in Figure 4.27. There are ten out of fourty-nine which is categorized as partial representation as shown in figure 4.28 and figure 4.29. However, there are five exhibitions which represent a mix of high and low formality.

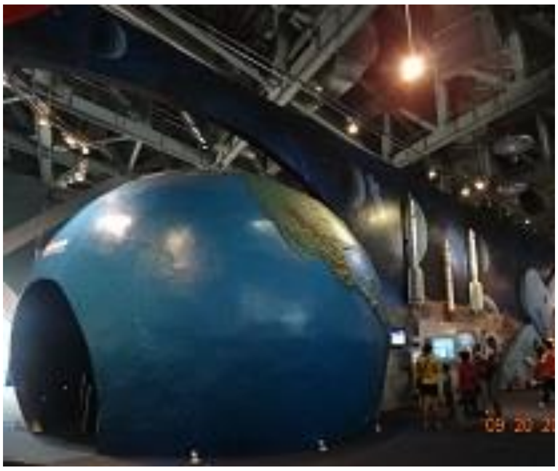


Figure 4.26: A globe as full representations at Guangdong Science Centre

Figure 4.27: Chocolate bar at The Mind Museum

Figure 4.28: Partial representations at The Mind Museum

Figure 4.29: Partial representations at Macao Science Centre

c. Texture

The three-dimensional representations promote low formality in its texture. The representations have mostly relief surface (fourty-four out of fourty-nine) as shown in Figure 4.30 and Figure 4.31. There are ten out of fourty-nine which is categorized as flat surface as examples shown in Figure 4.32 and Figure 4.33. However, there are five exhibitions which represent a mix of high and low formality.

Figure 4.30: Green Homeland Gallery at Guangdong Science Centre

Figure 4.31: Development in Guangdong Hall at Guangdong Science Centre

Figure 4.32: Inner-Space Track at The Mind Museum

Figure 4.33: Bioethics exhibition at Science Centre Singapore

4.3.2.3 Framing Modulation

The findings of strong and weak framing is reinforced by the power relationships and visitors' involvement of the three-dimensional representations.

a. Power relationships

Three-dimensional representations tend to contribute to the regulation of the interpersonal/affective relationships between the exhibits and the visitors. The element that contributes to the formulation of the power (hierarchical) relationships between the exhibits and the visitors is the exhibits' size and the vertical angle of view. The human-like size exhibits which can be viewed at an eye-level and which can be also manipulated by a visitor is the majority (fourty out of fourty-nine cases). This tends to create a feeling of familiarity and call for involvement and promotes weak framing as shown in Figure 4.34 and Figure 4.35.

Figure 4.34: Viewed at eye-level exhibits at Guangdong Science Centre

Figure 4.35: Frontal view exhibits at Macao Science Centre

The three-dimensional representations which have human like size or less are shown in Figure 4.36 and Figure 4.37.

Figure 4.36: Sports Challenge Gallery at Macao Science Centre

Figure 4.37: Food Science Gallery at Macao Science Centre

A three-dimensional representation that is large in size, can be viewed from a high and oblique angle and which cannot be touched, tends to create a feeling of diminishment and alienation of the visitor and hence promotes strong framing. There are twenty out of fourty-nine cases as shown in Figure 4.38 and Figure 4.39.

Figure 4.38: Large size replicas at Macao Science Centre

Figure 4.39: High and oblique angle view of the hanging exhibits at Questacon

Next with respect to the size of the three-dimensional representations which have large representations is shown in Figure 4.40 and Figure 4.41. However, there are eleven out of fourty-nine cases where the exhibitions have a mixture of small and large exhibits.

Figure 4.40: Large size representations at Space Dreams of Guangdong Science Centre

Figure 4.41: Large size representations at Robotic Gallery of Macao Science Centre

b. Visitors' involvement

The three-dimensional representations promote weak framing in its visitors' involvement. The representations are mostly where visitor can manipulate the exhibit (thirty-three out of fourty-nine) as examples shown in Figure 4.42 and Figure 4.43. There are twenty-eight out of fourty-nine which is categorized as visitor can only see the exhibit as shown in Figure 4.44 and Figure 4.45. There are twelve exhibitions which represent a mix of strong and weak framing. In conclusion, as far as the social distribution of the control over the communicative process established in the context of the science centres visited, the analysis from all the three-dimensional representations lead to the conclusion that the visitors are allowed a great deal of autonomy in accessing the exhibits and are also treated as socially equal partners which are highly motivated to get involved with them. The three-dimensional representations also promote a combination of strong and weak framing in different part of the exhibitions.

Figure 4.42: Visitor can manipulate the exhibit at Children Science Gallery of Macao Science Centre

Figure 4.43: Visitor can manipulate the exhibit at Human and Health Hall of Guangdong Science Centre

Figure 4.44: Non-manipulative exhibits at Technology Exhibitions of The Mind Museum

Figure 4.45: Non-manipulative exhibits at The Foyer, Questacon

4.3.3 Findings on Lighting Representation

Lighting is an intangible medium but it has an enormous influence on both the perception of physical space and upon the emotional response of those who enter these environments. These issues are addressed with a strong sense of aesthetics, functionality and quality of light to ensure quality visitor experience.

4.3.3.1 Formality Modulation

Lighting with respect to the surroundings in exhibition spaces suggest a mixture of high and low formality.

a. Degree of colours realism

The low levels of formality characterize lighting in two out of three cases, namely its degree of colours realism and degree of directionality. In specific, as far as their degree of colours realism is concerned, the lighting has thirty-eight out of fourty-nine exhibitions categorized as realistic colours as shown in figure 4.46 and figure 4.47.

Figure 4.46: Realistic colours lighting at Sport Health Gallery of Macao Science Centre

Figure 4.47: Realistic colours lighting at Q Lab of Questacon

There are eleven out of fourty-nine which is categorized as unrealistic colours as shown in Figure 4.48. Whereas with respect to their colour differentiation, thirty-nine out of fourty-nine have one or two colours (high formality). Only ten out of fourty-nine is categorized as three or more colours as also shown in figure 4.49.

Figure 4.48: Unrealistic colours at LED Experience Hall of Guangdong Science Centre

Figure 4.49: Differentiation lighting at Excite@Q of Questacon

b. Degree of directionality

As with respect to their degree of directionality, there are more use of diffuse lighting (thirty-three out of fourty-nine) in the exhibitions as shown in figure 4.50 and figure 4.51.

Figure 4.50: Diffuse lighting at Atom Exhibition of The Mind Museum

Figure 4.51: Diffuse lighting at Fun Science of Macao Science Centre

The focused light beam which represents high formality is less (sixteen out of fourty-nine) in exhibitions as shown in Figure 4.52 and Figure 4.53. In conclusion, all the previous results converge to a prevailing image according to which, the majority of exhibitions in the cases are characterized by low levels of formality.

Figure 4.52: Focused light beams at Robotic Science of Macao Science Centre

Figure 4.53: Focused light beams at Space Science of Macao Science Centre

4.3.3.2 Framing Modulation

The lighting property that plays a crucial role in determining the level of framing is the intensity of illumination of an exhibit in relation to the corresponding intensity of the surrounding exhibits. The observation suggests that the exhibits in the cases is not more intensely illuminated with respect to its surroundings, there is no implied hint to the visitor to draw his/her attention to it and hence the lighting promote weak levels of framing. In specific, thirty-four out of fourty nine have uniform of lighting everywhere as examples shown in Figure 4.54 and Figure 4.55.

Figure 4.54: Uniform lighting at MiniQ of Questacon

Figure 4.55: Uniform lighting at The Mind's Eye of Science Centre Singapore

In this way, lighting reduces the visitor’s control and hence leads to strong framing. The observation suggests that, intense lighting appeared less (fifteen out of fourty-nine) as examples shown in figure 4.56 and figure 4.57.

Figure 4.56: Intense lighting at Uniquely You of Science Centre Singapore

Figure 4.57: Intense lighting at Experiment & Discovery of Guangdong Science Centre

4.3.4 Findings on Degree of Linearity

The strength of each exhibit' connections to the other exhibits can be estimated by the existence of signs of explicit or implicit (e.g. morphological features such as common colour, background or lighting) reference to other exhibits, the proximity between the exhibits as well as the presence of connective elements such as the numbering of different parts of an exhibit or of a group of exhibits. The visitors are allowed to access each exhibit in a rather independent way as shown in Figure 4.58 and Figure 4.59. Twenty-eight out of fourty-nine exhibitions have no reference to the other exhibits. Twenty-one out of fourty-nine exhibitions have explicit or implicit reference.

Figure 4.58: No reference to other exhibits at Earth Science of Macao Science Centre

Figure 4.59: Independent access exhibits at Digital Home of Guangdong Science Centre

4.3.4.1 Framing Modulation

Findings on degree of linearity with respect to the surroundings in exhibition spaces suggest mostly weak framing as summarized in Table 3.10 in Chapter 3.

a. Proximity

The degree of linearity promotes slightly weak levels of framing in the proximity of exhibits as shown in Figure 4.60 and Figure 4.61. In specific, twenty-five out of fourty-nine exhibitions are categorized as distinct from the other exhibits whereas, twenty-four out of fourty-nine have close or overlapping proximity.

Figure 4.60: Segregated and distinct exhibits at Children's Wonderland of Guangdong Science Centre

Figure 4.61: Segregated exhibition galleries at the Atrium of Science Centre Singapore

b. Connective elements

The degree of linearity also promotes weak levels of framing in terms of connective elements between exhibits as shown in Figure 4.62. Thirty-one out of fourty-nine exhibitions are categorized as non-existence connective elements. Whereas, eighteen out of fourty-nine have existence connective elements as shown in Figure 4.63. In conclusion, weak framing is reinforced by the low levels of linearity with reference to the other exhibits, its proximity and connective elements. The observation suggests that arrangement of physical structure do not impose a linear way of access to the visitors. In relation to the social distribution of the control over the communicative process established, the results lead to the conclusion that the visitors are allowed a great deal of autonomy in accessing the exhibits. Visitors are treated as socially equal partners, highly motivated to get involved and participate.

Figure 4.62: Non-existence connective elements between exhibits at Basic Science of National Science Museum Korea

Figure 4.63: Strong levels of framing in terms of connective elements at Invent of Science Centre Singapore

4.4 FINDINGS FROM THE IN-DEPTH INTERVIEW

This section presents results and analysis from in-depth interview in answering the third question of this research:

> 'What are the design opportunities that will enhance visitor experiences in science centre?'

The responses reflected the interconnected yet diverse nature of design roles in science centres. Findings conclude five themes represent central values and important recurring concept findings which strike at the core of the exhibition design process. They are:

i. Invoking interest
ii. Delivering the message
iii. Connecting personally
iv. Designing inclusive/immersive experience
v. Balancing the constraints

Before addressing each of the themes individually, it should be noted that the five themes are not wholly exclusive or distinct from one another. Rather, the lines between them are blurred and frequently overlapping and interrelated. Given the organic and integrated connection among the themes, each theme is discussed in relation to the other themes, as well as individually. The findings carry independent significance relative to the data, but more importantly when viewed within the context of each corresponding main theme, they combine to support the breadth and reflect the essence of each primary theme. All the related comments during the interviews are referred in Appendix IX.

4.4.1 Invoking Interest

The first theme, invoking interest, focuses around the concept of the science centre's need to establish an identifiable image as well as offer a rich and cohesive experience through its exhibitions and overall environment. This theme also relates to reflecting the overall goals of the centre and the nature of how and what the science centre conveys to those who walk through its doors. Each separate component of the centre - the building environment, the staff, the exhibitions, the interactive exhibits, and the descriptive content - all work together and contribute to the story that the centre's communicate to its visitors and to the overall identity of the institutions. Participant 1 explained regarding exhibition design decisions and current practices at Questacon in comment (1). Exhibitions are a key means to reach its visitors, as noted in this statement from participant 2, describing the Science Centre Singapore exhibitions department:

> The goal of our exhibitions is to inspire a love of science and lifelong learning through cognitive pathways. To achieve this, we offer exhibits on a broad range of topics, employ a variety of media and use the science show to demo the natural wonders that appeal to audiences with diverse backgrounds, interests, and learning styles.

As the statement suggests, exhibitions are important to forming the identity of the science centre. However, many other aspects of the centre also contribute to the essence and the identity it projects both externally and internally. Each new exhibition design idea made a significant contribution to the centre to transform the institution and tell new themes.

Table 4.7: Exhibition planning consideration

Planning consideration		Explanation
1.	Topic and brief	Research of previous exhibitions and predominantly visual reference material on the topic; analysis of the specific requirements of the brief, intended outcome anticipated audience and their requirements.
2.	Project limitations	Budget, timeframe, available resources, other requirements such as launch, media, dignitaries.
3.	Overall parameters	Travelling requirements, scale and life expectancy of the exhibition, audience considerations.
4.	Site	Spatial limitations and constraints; interior linings, colours and mood; natural lighting levels and lighting infrastructure; available services such as power, data, water, compressed air, air conditioning and air movement; floor loading capacities; building infrastructure and requirements including maintenance and access; regulatory signage; visitor access.
5.	Regulations	Building Code of Australia, Work Health Safety requirements, Fire regulations and ingress/egress routes and circulation, Australian Standards, the Disability Discrimination Act.
6.	Fabrication	Techniques and technologies, available and affordable materials, colours and finishes, printing methods and materials, local services, timeframes and cost.
7.	Style	Title, visual brand and marketability; relevance, interest, engagement, enjoyment, mood and feel, stimulation of interest; the style of the exhibition needs to differentiate and if possible help support or provide some frame of reference for the topic in some way – create a connection between the experience and the messaging while helping to make sense of the collection of exhibits and experiences.
8.	Layout	Circulation, location and position of exhibits to maximise the best visitor experience, theming, zoning, visitor queuing, noise and lighting in the galleries, dwell time at exhibits, physical accessibility.
9.	Staffing	Gallery staffing, staffing of exhibits, supervision.
10.	Maintenance and mobility	Ability to remove exhibits from the floor for repair; ability to efficiently transport, install and de-install exhibits; reliability and maintenance of exhibits, access for maintenance, replaceable parts, common details in the assembly.
11.	Format and messaging	Complexity of exhibit use, complexity of the message or intended outcome, multi-user vs. single user exhibits, social interaction, whole body or bench top exhibits, learning outcomes, accessibility of graphics, clarity of illustrations and instructions, does the exhibit effectively deliver the intended concept.

Through the planning and transformation process, the centre sought to create an identity for itself. Participant 1 outlined that from a design perspective the list of concerns in planning will vary from project to project but typically include 11 considerations as summarised in Table 4.7.

Participant 1 comments denote that from design perspective, science centre have many concerns that add complexity to offer a rich and cohesive experience. The theme nurturing visitor interest and curiosity represent essential values and important recurring concepts that strike at the core of the exhibition design process. The findings addresses a variety of sub-themes relative to the following perspectives pertaining to creating interest/curiosity: (1) Creating an identity for the science centre; (2) Allowing for interest, curiosity and variety; (3) Reframing content with a different lens; (4) Providing wonder and surprise; (5) Allowing for dramatic effects and (6) Dealing with current issues affecting the global community. The following section looks specifically at how identity and meaning of the science centre itself are conveyed to the visitor.

4.4.1.1 Creating an Identity for the Science Centre

As is true with all science centres, the findings suggest that the cultural institution projects an identity to the public. When people visit a science centre, see its marketing materials, or hear others talk about a science centre, those people form an idea in their minds of what the centre is, what it means and what it can offer them. Aligning the internal sense of character or identity of the centre with a corresponding external image is important as an institution. As commented by participant 3 regarding the external building appearance:

> The criteria were first of all it should be a landmark building and actually the winning project was not a landmark building, so we had to change the exterior. It’s a fact. The Foundation said to me we will not give to that

> project money, but also it was important that the operation of the building was intelligent.

According to participant 3, The New Experimentarium building should have these unique criteria as a city landmark. The design operates as an intelligent building is another important factor. It further creates science interest and curiosity towards the public. Participant 4 discusses on the idea of experience in museum:

> Throughout history of museums, the institutions have all learned from precedent and making museum better in communicating its purpose. Experience is what museum offers. Besides, it can never replace the learning in virtual or multimedia. Museum visitors come for the same reason to learn and quest for knowledge. You see the person next to you seeking for that something. An individual tries to connect to an idea or concept.

Participant 4, indicates that from a broad perspective science centres have many similarities, but they differentiate themselves by the way they are organized, the people who contribute to them and the focus the centre chooses to put forth (refer comment 2). Decisions were made on how a science centre will place value on projects and ideas, the centre's sense of identity of what the place is and what it should be.

4.4.1.2 Allowing for Interest, Curiosity and Variety

In general, all science centre strives to convey science concepts, issues and its related technology in application to human life and the environment. By observing the science centres exhibitions, the differences to approach this goal rests in the variations of what aspects of science are addressed in the centres. Each separate component of the science centre - the staff, the exhibitions and the descriptive content - all work together and contribute to the message that the contents communicate to its visitors. Participant 5 highlighted the importance of staff training in communicating science (refer comment

3). He emphasized the right technique in facilitating inquiry based learning in science centre. Furthermore, in designing an exhibit that will inspire interest and curiosity, Participant 3 emphasized the processing fluency as the key to attract and fascinate science concepts:

> If you go to an exhibit only 5% of the visitors read the text… Therefore, you need to make the design of the exhibit as explainable as possible. There is a paper called processing fluency...it is actually saying that if you understand what you're supposed to do and then you are interested and you can be put into flow, and then you understand what is going on. Processing fluency is very important in the design of the exhibit.

He believed processing fluency is a design tool to benefit visitor psychological behaviour in approaching hands-on exhibits. He also stressed the need to challenge one's mind as the flow theory recommended (refer comment 4). The flow theory is practical in designing visitor experience to facilitate curiosity and virtuosity. It is important that science centres provide cognitive understanding in delivering the message. Participant 3 also revealed the stages of visitors' cognitive experience (refer comment 5). He mentioned that emotional understanding comes from positive evaluation that happened in many stages. These stages of translation in cognitive understanding lead towards the meaning making in exhibition experience.

4.4.1.3 Reframing Content with a Different Lens

The build up of a transformation in the visitor is the most progressive offering as suggested by Pine and Gilmore in The Experience Economy (1999). It is described as a coordinate system with the X-axis being whether the visitor is active or inactive participating in the experience and the Y-axis being whether the visitor absorbs or is immersed in the experience. A successful experience needs to involve all four realms in the coordinate system: Educational experiences, entertaining experiences, aesthetic experiences and escapist experiences. Participant 3 believes the centre should endeavour for transformative visitor experience. His quote (comment 6) emphasizes the importance of aesthetic and escapist experience in balance with entertaining and learning experience in a science centre. Exhibits display, informative text, visuals, audio and multimedia components are also utilized to help provide a more concrete experience and contribute to the lens through which visitors view the subject on display. The integration of all these elements adds to their collective impact - there is strength in the gestalt of combined elements working together to tell the same theme.

Science Centre Singapore (SCS) rotates exhibitions in the temporary gallery regularly, featuring information and stories about different science and technology. The stories told in this gallery help contribute to the focus and breadth of the centre. Other new temporary gallery spaces, as well as collaborative or travelling exhibitions, also provide the opportunity to showcase different types of stories and vary the presentations. The flexibility to rotate exhibitions is important for making the centre feel new even if visitors have been there before. It is critical to making such changes in order to encourage people to return. Participant 2 explained (refer comment 7) the SCS's efforts to show the science theme and make changes to keep the issue current. As he indicated, having exhibition spaces that allow for new stories and regular changes keep the science centre fresh and offer visitors new experiences. To this end, new efforts have been initiated to improve and value-add to students' and visitors' experiences. The diversity of the Singapore's communities and target visitors to this centre is the reason for a wide range of content throughout the exhibition galleries. He further indicated the importance of the gallery in offering the flexibility to share science collection and community story. His quote (comment 8) emphasizes the centre's needs to display artifacts that represent strengths in the collection, but also strives to select objects that will be of interest to new people, as well as core returning visitors. Participant 4 highlighted the importance of controlling variety of feeling in communicating science exhibitions (comment 9). She believes there must be a variety on a broad level, as well as on a personal level, like using big scale and beautiful objects that attract special kinds of interest. She discusses on the idea of connecting science through art and science:

> In communicating science, it has to be correct, follow by making it easy to understand and beautifully expressed - through artistic way. I always told the artists making the exhibits 'you have to be correct first before you make it beautiful.' I believe art and science should be constructive in exhibition making. I talked to the designers and scientists about all the different ways that they might connect to design through storytelling.

Participant 4 communicate exhibition design with aesthetic experiences. Artifacts do more than just convey a feeling for the order of magnitude in real life; they often constitute an aesthetically attractive piece of art. Admiration for the beauty of an object may be the starting point for future exploration, and art, for this reason, has the function of attraction.

4.4.1.4 Providing Wonder and Surprise

Despite the variety of exhibition changes, the benefits of renovation, the redesign and efforts to put forward an identity for the science centres, the primary focus of the centres has not changed. The main emphasis of the science centres for its variety, diversity and programming remains the same as what the early science centre established in the 1960s - a focus on exploring science (Oppenheimer, 1968). The exhibitions need to tell the science phenomena. For example in SCS website:

> Be amazed by our Tesla Coil demonstration, a highly dramatic and electrifying live demonstration of high voltage electricity. See this 3.5 million volt coil in action, generating electrical arcs of up to three metres.

Participant 2 stressed the centre's need to show the effects - of its exceptional wonder and unexpected intense - and emphasized that those things are at the core of the centres attraction. He shared the centre's vision to convey the wonder and the excitement of learning science. Some other varieties are Fire Tornado Demonstration, Waterworks Exhibition, Snow City and the IMAX dome theatre. Grand scale is much more than the volume or area of the space containing the experience. It also refers to the way the visitor feels within that space. Scale could be used to distort the perspective of the audience or allow them to feel as though they have roamed into a new world. IMAX allows viewers to take on a new perspective. It achieves that effect by stretching the giant IMAX projection screen into the audiences' side-line vision, extending it beyond their normal sight lines. On a smaller screen, this experience is not nearly as effective. Playing with scale helps create a simulated authenticity, which allows for wonder and surprise. John Dewey (1938) asserted that an experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his environment. In order for these transactions to occur, designers and developers must be conscientious about exhibition design. It is important to be intentional. Spectacular Design is a method of producing an exhibition that is intended to transport visitors to new locations, engage them in a story being told, and have a lasting impact. When this is the intent, designers employ plot, dramatic effects, grand scale and authenticity to make it happen (Counts, 2009).

4.4.1.5 Allowing for Dramatic Effects

Participant 2 believes the centre should aim to show people what an amazing place SCS is. Sharing all the stories and things that make SCS what it is - all fuel interest and excitement for visitors. As he expressed:

> What's the goal here... in a way to affirm science wonder for the people who've seen it live… and it's also to give them a real strong sense of dramatic effects. I think it's also to surprise them with how influential science is.

He agreed the more dramatic in the aspects of science that is represented in the centre, the wider the range of impact on visitors. By using special effects (lighting, audio, video, and darkness) authentic experiences can be enhanced. Dramatic effects are not just for shows at theme parks. They have also been used in museums to create eloquent visual environments. Light and darkness are simple, but effective methods for adding drama to exhibition design. The Universe design uses light to create a mood. If this exhibition were flooded with overhead lighting, the stars would not inspire visitors to gaze above or interact with the hands-on exhibits. A less common design element found in a science centre is plot. As illustrated in attractions experiences, a strong plot will engage participants' emotions and pull them into a story. It can enhance a theme or incite emotion in visitors.

As shared by participant 4 (refer comment 10) much like story or a novel, a plot is a strong conceptual story with highs and lows. In the Poetics, Aristotle observes that a well-constructed plot consists of a beginning, middle and an end. Plot requires a source of "astonishment" or "surprise" to captivate audiences (Artistotle, 1996). This is created by the presence of a conflict, tension, or dramatic shift in the storyline. For an exhibition, it may be a particular object that is revealed. The parts of the exhibition must be a "connected series of events" (Aristotle 1996, xxiii). Tension builds when a connected floor plan leads to a high point in the exhibition, such as a "wow" artifact. Participant 4 also emphasized the connection with the subject as important in exhibition design to tap the visitor interest.

4.4.1.6 Dealing with Current Issues Affecting the Global Community

In preparing for new exhibitions, the social relevance enables a more precise question to be asked. What technological knowledge is important for the visitor as a member of a society? Social relevance refers to those everyday decisions that are fundamental to the quality of life and the future of mankind. Participant 3 shared the centre new exhibition concepts:

> We have some concepts that we have to make… a new exhibition where we should stimulate people interest in exercising, doing fitness, be healthier. Based on research, we come up with hypothesis about how you could actually nudge people to exercise more…the exhibition would be a kind of a room for stimulating the interest in your body and that way to be healthier.

As he indicated, in preparing for new exhibitions, social relevance are the intended message. The hands-on exhibits are a result of scientific research on how to nudge people to be more interested in the subject matter. Participant 4 expressed her concern during early design development. The crucial question in designing a new museum involved the topics to be addressed. What do we want to teach the visitor? Science and technology have developed an immense range of subject matter. As she expressed (comment 11), topics that justify the expense of erecting new galleries are, for example, energy, transportation and pollution are fundamental in the global community. It is important to create an interest and spark curiosity in topics of great social relevance.

The interview participants' responses highlighted that designing and developing exhibitions is a complex and organic process with many factors to consider - content, message, exhibits, layout, flow, media, lighting, timeline and many other issues. In order to nurture visitor interest and curiosity, the participants discuss physical and conceptual ways to establish its identity, share science and technology and offer new experiences to it visitors. To a large degree, the image projected by the science centres are evident in the exhibitions represented and the manner in which they are conveyed.

4.4.2 Delivering the Message

The second theme, delivering the message addresses some primary considerations science centres take into account in their exhibitions in effort to reach visitors on as many levels as possible. Everything about the way an exhibition is conceptualized and designed impacts how it will be received by visitors.

The exhibition design method, physical space, atmosphere, comfort, message, content, context, design elements, color, lighting, flow, and objects - they all can promote connections. The findings highlights that there are several aspects of an exhibition which can contribute to cultivating visitor connections. These responds are described in this subthemes: (1) preparing to deliver a message, (2) setting the scene, (3) designing a whole through the parts, and (4) providing layers of information.

4.4.2.1 Preparing to Deliver a Message

An opening to any exhibition exploration is simply by reading the title. As the visitor may have read the title even before setting foot in the museum, is it important to select a title which will be clear and marketable to the general public. Participant 4 stressed the need for brief, but suggestive titles to elicit personal interest:

> (Exhibition) titles are important to the marketing department because when we create collateral, you want something that is going to be easy to market and easy for people to grasp and understand as they visually see it.

As she expressed, exhibition titles are important - they can serve to introduce the topic, set the overall theme, and provide visitors with enough insight to the message behind the exhibition to draw them into the museum. Visitors begin to reason the potential value of the topic and message behind an exhibition in numerous ways. Generally, there is a need to craft exhibitions that encourage visitation. The theme and branding of new exhibitions can increase marketing in science centre, as mentioned participant 1:

> New exhibitions promote visitation and repeat visitation. Questacon can be seen to be a dynamic institution. Clearly branding exhibitions makes it easier to market new offerings to the public and easier to negotiate their hire by other venues as part of our national and international travelling exhibitions programme.

Accordingly, the exhibition design and the overall experience a visitor has in the exhibition space will ultimately deliver the message. The exhibits, the space, the flow, the overall design - these elements of the exhibition all impact the visitor's experience. Every detail about how the design is conceived affects how visitors will react and connect with the exhibition and its content. The design is an important part of the message explained participant 6:

> I think the way you have [an exhibition] set up has a huge impact on how people view what's there...the kind of design we do really is part of the overall experience and it helps people… You send messages with the kind of design you do as much as the topic you're doing and what exhibits on display. The design is all part of that message that you're sending out. So, I think it's important in the way you lead people through the exhibitions, what you show first…what you give more emphasis to.

As she suggested, the way an exhibition is designed should reinforce the message and content behind it. Accommodations for diverse visitor values, interests and learning processes is a major consideration in design, yet offers difficulties as commented by Participant 5 (refer comment 12). Although sometimes hard to achieve, he commented there are awareness on the ideal way to encourage visitor into having a response. The idea of nudging and stimulating visitors' interest is just as important in convincing a message. The objects, colors, and path through an exhibition are most effective if selected for reasons which support the idea they are striving to tell. According to participant 3, in preparing for new exhibitions, the concepts are the intended message.

A clear message needs not to be instructive. In decision network theory, nudging is usually more effective. The hands-on exhibits are a result of scientific research on how to nudge people to be more interested in the subject matter. If the design blends smoothly with the exhibition it helps convey the theme, rather than distracting from it. Transparency of the design elements can add to the affectivity of communicating the message. Sometimes the aspects of an exhibition design which go unnoticed can be the most important to delivering a message, noted participant 1:

> As at the MiniQ furniture, that is about scale. 0 to 6 is massive age difference ability and physically, so within that space there are a few spaces for very tiny kids where everything is at various scales. We also have to recognize parents and guardians taking their children through. So that is why it is a separate set of experience as well, older and the younger ones …trying to communicate scale.

As he suggested, how the message is conceived physically all play into designing the message that will be received. The targeted audience for a particular exhibition is an important consideration for the science centre relative to the design. Providing elements in the design that make the audience feel welcome and comfortable in the exhibition can go a long way in terms of helping visitors find a connection with both the exhibition space and the message. The selection of colors or objects, as described by participant 4, are both design elements which can provide visitors with a sense of comfort and familiarity:

> Maybe the most important thing that design can do is get people a kind of comfort level. Like, this feels familiar, or they're speaking to me or there's a color that speaks in a more positive way. Part of it is trying to understand it…design needs to speak to them through the combination of things.

As she explained, the Mind Museum seeks to carefully chose and align the specifics of an exhibition design with their target audience(s). The designers hope to combine design details that will speak to visitors, but only if the overall space feels inviting enough will it make them look closer. The data further suggests that objects at the Mind Museum are presented in a context to provide both a point of entry to science and to help visitors to shape their experience and ideas. The display elements, informative text, visuals, audio and multimedia components are utilized to help provide a more concrete experience and contribute to the lens through which visitors view the objects on display. The integration of all these elements adds to their collective impact - there is strength in the gestalt of combined elements working together to tell the same story. Based on the descriptions of science centre exhibitions, when elements are combined effectively, the visitor's exhibition viewing is transformed into a whole experience.

4.4.2.2 Setting the Scene

Science Centres are an environment where science discoveries, visual imagery and interactive technology can meld together to elicit new personal connections and experiences. The combination of elements in a science exhibition can offer visitors a unique experience in a space that cannot be found elsewhere. Participant 7, described exhibitions as pushing the boundaries of learning:

> [Exhibits]…can be wonderful, nowhere else can you go into these spaces that kind of transform floor space into hands-on settings and explore topics that you can't do by reading a book. This is always the example.

As she suggested, museum exhibitions have the potential of being immersive environments that bring ideas and science to life. The space in a science gallery can be designed to temporarily transport visitors to another time and place. The layout, visual appeal, and feel of an exhibition space set the scene to immerse visitors in a transformative experience. The physical space has an impact on people, explained participant 4 (refer comment 14). Her comments support the notion that whether through the layout, the lighting, or the objects, the overall impression of an exhibition space needs to make an impact to draw in visitors and make them want to see more. Participant 6 emphasized the importance of an engaging physical exhibition space:

> It needs to be interesting… being engaging is the most important. A lot of people, specifically now with technology and just the level of where we are in terms of entertainment and being entertained, it has to compete with that because as a museum, we compete with this whole leisure time activity…it has to be engaging enough to compete.

As she suggested, although the Museum offers unique experiences, it must compete for visitors with other leisure activities, including movies, gaming, and other venues with high-end, interactive technology experiences. Staying competitive with entertainment options driven by technology is particularly important when it comes to younger audiences. Integrating technology into the Questacon is always in the design plan, described participant 7, particularly for interactive spaces designed with excitement in mind, it was the design factor:

> We knew for the ExciteQ's gallery we wanted technology to be a tool for connecting visitors to science and senses. So, technology was always part of the plan.

She acknowledged that using technology in the Questacon was important to draw and engage certain audiences. Technology was included as a design element that would make the exhibition interaction more conducive to helping visitors make connections with science. For some visitors establishing connections might be aided by providing interactive technology; for other visitors, immersive contexts and informative graphics might be more effective in forging an understanding of the content presented. Since visitor age and reactions vary, design methods should vary as well. Design is the key factor for experience, stressed participant 3:

> Design is a key factor. If you do not remember all this good points, then you design an exhibit where people cannot understand what is happening and the function is not quite clear, you don't use the idea of nudging and so on and then you got frustrated visitor that walk out and will never come back again.

His remarks suggest that the experiences that are delivered to visitors in science centres must be designed in a way that makes one understood, feel good and transformed. Ultimately the end goal is to design an exhibition space which help visitors connect with the content - connect with the science phenomena. As stated by participant 1 (comments 15) he suggested that although the exhibition design is built on details, the overall look and feel created by the combination of those details is what sets the scene for visitors to enter an exhibition ready to interact with the space and walk away with new information.

The variations of exhibition gallery space are a part of Experimentarium renewal and expansion as commented by its Executive Director. As stated by participant 3, the variation of light and dark galleries suggests change of mood happening in various levels (refer comment 16). The exterior design is as equally important in determining the overall impact of a science centre. The exterior physical form is a landmark and the interior exhibition galleries are the setting for different science theme. The physical space is the hook to the emotional connection - which, according to Participant 4, is what visitors will take away with them:

> I think it's the power of being in a physical space that challenges you to connect to the information in some way, it's the whole, I believe in the whole aesthetic…. I'm much more interested in the power of museum learning to stimulate people's imagination and kind of the affective outcome, their emotional reaction to a topic or to an experience.

She stressed that creating a whole aesthetic experience is what will leave a lasting impression on museum visitors. As commented by participant 3, the application of scenography in science centre is necessary:

> In the Experimentarium there is no scenography…when I started 25 years ago I said scenography is not necessary. Today I would say that you have to immerse your visitor into a kind of kingdom and you must used scenography in a gentle way to nudge the visitor to feel that they are in

> an environment where they are supposed to be curious and so on. You need scenography but scenography alone is not enough.

He acknowledged that the used of scenography is expected in today's experience economy. However, hands-on exhibits will still remain the real tool for informal learning. Designing a complete exhibition experience requires careful consideration and assembly of many separate parts.

4.4.2.3 Designing a Whole through the Parts

As suggested by a number of the respective interviewers, the design whole is more than the sum of its individual elements. The benefit of four kinds of experiences is suggested by participant 3. He commented that repeat visitors are a result of 'pleasures of the mind' when they had all the four kind of experiences (refer comment 17). Science centre needs to deliver a successful experience that involve all four realms of educational, entertaining, aesthetic and escapist experiences as an underline theory by Pine and Gilmore (1999). The design of an exhibition includes every small detail that surrounds the visitor, and the combined impression of all those details is what impacts the experience a visitor will have. However, there are the limitations in practice as described by participant 1.

As he commented, designers are cautious of the visitor experiences and do suggests on varying the experiences where ever possible through differentiating the feel from one gallery to the other (comment 18). The designed elements and the way a visitor connects with them form a designed experience, as explained participant 4:

> I think what important to remember is that it is all design. Every exhibit you walk into, it's all about the design. When you as the visitor, experience an exhibit, what you're experiencing are the interactive and designed spaces. ….to the visitor, what matters is what my experience is in that gallery and my experience in that gallery is a designed experience.

According to her, a designed exhibition experience is shaped by the integration of all the parts. This kind of integration should result in a fluid exhibition design, immerse like reading a good book. Participant 2 also noted the need for the integration of exhibition elements:

> There has to be an integration of elements… and by that I mean the idea, the exhibits, the design and the interactive should have a connection. It should be integrated. When kids explore [the Market] gallery, it feels like they're walking into the street.

As suggested by his comments, unification and integration are required to convert a gallery of objects, images, and exhibition elements into a space that feels like a Market street. Part of the design challenge faced by the SCS, and all science centres designing exhibitions, is finding ways to make all the pieces work well together and contribute to the whole. Another common issue in designing exhibitions is overcoming museum fatigue as highlighted by participant 1:

> It's important about pacing, giving this new experience each time. This is important as museum fatigue aspect of them. It is presumably over the visit, their interest start diminish as they go through so we try to make them engaged as much as possible by differentiating the experience there. Each one is different and the moods of course to support that.

He suggested that modulate different experiences be considered in the layout. Visitor interest is controlled by pacing and this benefit how an exhibition will be received. Participant 4 understood the need to meet this challenge to integrate design elements. She reflected on the core aim to be aware of the interconnection established between all the design elements:

> The colors and the graphics worked extremely well throughout the space. It was a huge consideration. We strove to make sure that all the spaces related and that throughout the use of fonts, and graphics, and color palettes that there was this constant relationship between the spaces, yet a certain amount of individual identity to each.

As she emphasized, the individual design elements carry weight and importance of their own, but they also should contribute to the larger complete experience. The interplay among energized spaces and how the contemplation spaces relate to the information presented are critical in communicating content to visitors. To create a strong exhibition design, the layout must be balance. Similarly, the separate elements and the whole look of the exhibition must be aligned with the content and descriptive labels. Good design or bad design can make or break an exhibition; design can promote an evocative experience for visitors or crush the potential to help visitors connect with meaningful content. Participant 1 highlighted the meanings of immersive in science centre through its connection with the exhibit:

> Questacon point of view is that in exhibition design, the most important thing is the exhibit and not the surrounding. Immersive in exploring the exhibits is the unique thing that we offer - the rest of it; the immersive feel is there to support it. The 'pay-off' to the public, is the experience they had with the exhibits…because we present different exhibition and each have a different identity, branding and feel to the design, we do it for the marketing perspective.

Participant 1 commented that experience with the exhibits is the real benefit of immersion in science centre. The travelling exhibition also benefit from these quality exhibits that offer unique identity and feel to the design. Participant 3 comments on the importance of scenography in science centre exhibitions. He suggested scenography is only a tool to nudge the visitor to be curious with the context and be more immersed in the hands-on exhibits (refer comment 19) . Furthermore, he stressed the crucial role that design plays in providing visitors with a rich exhibition experience.

He argued that the design must unify the content, objects, and exhibition elements in a comprehensive and powerful way in order to reach visitors (comment 20). He acknowledged that scenography acts as a flow in the narrative context. The object and information is enhanced in an immersive environment. Participant 3 suggested merging elements to create a cohesive exhibition is necessary. Not only must the parts of an exhibition be assembled in a manner that generates a powerful and meaningful whole, the design team must take into account the variety of visitors who may pass through the exhibition. One way to address the range of possible visitors in an exhibition is to introduce different levels or layers to the presentation of content in an exhibition.

4.4.2.4 Providing Layers of Information

Layering information can be achieved by varying the depth of information provided, or by using different formats and styles to engage visitors. Participant 6 described how addressing visitor needs and layering information are part of their design process:

> We always think when we go through a design process; we try to always think in terms of: what is the take away message? How is the visitor going to react to this? Does this meet the basic audience visitor needs? We always try to provide a study track for those who have more time and what to dive in deeper into a message, and we also try to provide a fast track for people who have a more limited time and interest, get the big picture and move through an area a little more quickly.

She acknowledged the need to design with the understanding that different visitors plan to spend more or less time in an exhibition, and expect to gather different amounts of information from their visit. Some want to emerge with detailed knowledge; others just want to understand the primary message. Presenting exhibition content at varying levels of detail provides enough depth to meet various visitor needs. Since different people also absorb information in different ways - depending upon age, education, background, interests and a whole host of other factors - allowing for multiple levels of visitor interaction is important. An exhibition design has to be engaging on so many different levels - visually, sensory, intellectually, emotionally. Designing layers into the presentation of information can provide a cross-section of planes through which visitors can make connections with the exhibition content. Layering the exhibition content is in line with Gardner's theory of learning styles and multiple intelligences (Gardner, 1983), which as participant 7 explained, applies to everyone.

As she noted, some visitors need a nudge of encouragement when it comes to looking more closely at museum exhibitions (comment 21). Using layers can be a means to draw people in, by getting their attention through an outwardly obvious and engaging layer, and using that layer to encourage visitors to look more deeply below the surface. According to Serrell (1996), exhibit planners frequently use the words "layers" or "levels" to describe the way exhibition information is organized. Relative to exhibition labels, she suggests that the types of layers or levels which prove to be the most effective to covey a hierarchical nature are: purpose, intrinsic complexity, and amount of time required for visitors to use them.

The science centres provide a mixture of learning opportunities for visitors by varying the topics, design elements, interactive and media used in exhibitions. Layers and multiple points of entry for making connections are possible through variety. The Powerhouse Museum tries to offer variety, said participant 6:

> We try to make sure there are a variety of things…people have different learning styles, putting audio and video, putting interactives to engage people.

Participant 1 also expressed variety and layering of opportunities as strengths, particularly in the Climate Change Exhibition (comment 22). Both participants indicate that the museum offers exhibitions with variety on multiple levels - in the kind objects displayed, the sensory experiences provided, the layers of information presented, the learning styles implemented, the types of media utilized, and the levels of interactivity afforded to visitors. The layering of all these individual design components contributes to the strength of the whole.

4.4.3 Connecting Personally

The theme, connecting personally, discover how science centres create unique educational environments for active exploration, fun and enjoyment. The interview participants' responses highlighted the creation of personal connections is by targeting and understanding their audience. Such insights may be applicable to support informal learning and visitor diversity. Science centre intended to fulfil educational roles and this is reflected through the design process. A variety of means is implemented to promote personal connections for visitors on multiple levels through: the science content, the arrangement of the design elements and physical exhibition space, the exhibits on display, the marketing and other consideration of visitor interests. Participant 1 highlighted these challenges (refer comment 23).

Science centre intended to meet educational roles and this is manifest through the experiences produced by interactive exhibits. Participant 8 commented:

> The philosophy is simple: to mimic the scientific process by conducting or simulating experiments, enabling the visitor to make her own discoveries. You could say the visitor can direct his questions directly to nature, and deduce the answers from the outcomes of the experiments.

As he mentioned, design exhibits present real science discoveries from conducting or simulating experiments. Participant 1pointed out:

> We aim to provide real science experiences preferably relying on open-ended investigation. Our exhibitions are individually styled, themed and branded to provide the audience a wide variety of experiences, reduce visitor fatigue and aid the recall of ideas and experiences through differentiation of design, space and styling.

Ultimately, visitors must draw connections for themselves by identifying science concepts from theme that relate to their own lives; they must make a connection by interacting with the exhibition space. As described by participant 4, she defines ideas relative to the institution's core purpose:

> The core purpose is to help people to make a connection to science. The personal realization is very important. Individuals feel connected to science...You're presenting things…that allow people to see how they're connected to science that it is around us… it's not just a presentation of facts, and if you're feeling a personal connection to something, I think that implies that you're learning.

Her comments emphasize the idea that visitors must make connections to the exhibitions that are derived from their own personal curiosity in order to truly be meaningful and real. But how can the science centre find ways to encourage and sustain this connection for its visitors? The strategies to provide an experience should attract visitor's interest, as mentioned by participant 8:

> Proposed experiments should attract the visitors' interest. Therefore, e.g. phenomena related to everyday life of the visitor or the person are good to include. Presenting an enigma often works, sometimes the visitor can even be tricked into involving himself. Humour helps!

As he mentioned, enigma such as mystery or puzzle, design tricks and humour can attract visitor's interest and encourage one to be involved in the exhibits. Science centre strives to help people connect with science by drawing them in with a variety of visual elements, presenting objects, providing sensory experiences, and sharing a broad range of science concepts visitors may find recognizable or engaging. All the elements must interrelate - the exhibition design must support the theme and be tailored to a specific audience. As participant 1 suggested, space can be a limitation, therefore modulate different experiences is applied (comment 24). The way all elements interact impacts how an exhibition will be received: from the selected content and focus, to how it is designed, and from who designs it to the audience for whom it is intended. This section explores a full range of factors which contribute to promoting personal connections with science centre exhibitions through the following sections: (1) taking science home; (2) making science accessible; (3) providing relevance by drawing on personal and the social environment and (4) creating new interest by engaging with aesthetic theme.

4.4.3.1 Taking Science Home

Science centre hope to address interest in science. The planning and design of exhibitions is aimed toward this goal. As expressed by participant 1:

> Questacon produces exhibitions to present and communicate a broad range of science themes to a broad audience. We do this primarily to engage youth, students and families in science and hopefully inspire some to make it their career. Through our exhibitions we attempt to make science accessible to as many as possible by making it appealing and enjoyable. Critical to this is the interactive experiences we produce where visitors can experience science phenomena and ideas in a safe and fun way that are not necessarily able to be experienced through other media.

A key goal for the science centre is to find ways for visitors to leave the centre feeling connected to science. However, fostering this connection is not always easy to do. Participant 5 share his thoughts on science centre's hope and challenges. His remark emphasizes the fact that it can be difficult to reach people interest through science (comment 25). He pointed the many factors that affect the reason to visit a science centre.

According to him, the reality of museum visit is a challenge when visitors have to balance the precious source of time, value and money (comment 26). Participant 7 also acknowledged the challenges to museum visit. Her quotes share the fact that it can be difficult to reach people through science and have them feel connected with the material being presented (comment 27). However, if science content is presented in a way that affords interactive and taps into some aspect related to visitor's curiosity, then that content can promote a connection and make science understanding more fun. Getting through to visitors is about getting past the surface and striking a chord at a personal level. As Participant 1 proposed, making the visitor experience themselves in the centre and understand about what they do is critical to unlocking an opportunity to encourage personal connections with the content (comment 28). The galleries addresses the ways Questacon can open people's mind to science by making them experience it and offering some aspect of understanding to take home.

4.4.3.2 Making Science Accessible

A crucial requirement for helping visitors discover connections with science is to ensure the science centre and its contents are accessible to people. Achieving this means the layout of the centre, the design of the exhibitions, and the format of the actual content all must be presented in a way that is approachable, relevant and easily understood by a range of audiences. The initial impression of the centre must be such that visitors feel comfortable. The SCS tries to provide a welcoming environment and enough variety to offer something for all visitors.

As participant 1 suggested, the overall array of experiences available in the centre is important in making visitors feel they can explore, access, and learn from the exhibitions within (comment 29). Once gaining an initial sense of comfort, visitors must find the contents accessible on multiple levels as they continue to look more closely at the exhibitions. Every aspect of the exhibitions should support the content and contribute to the whole experience. Specific ways to encourage accessibility and making connections with content are evident in the following examples related to: exhibition flow, labels, scaffolding materials, and opportunities to interact. Participant 1 described how the flow of an exhibition impacts the comfort and accessibility of the exhibition (comment 30). Participant 7 commented on accessibility and making connections with exhibitions content:

> In the foyer, we got quite a few ways that try to put a flavour to what you might find at the gallery so that a person who enters the gallery for the first time get a sense of it. There's a lot of movement, activities and this is what Questacon is all about.

These two comments support the idea that careful planning and providing wayfinding cues in the exhibition space minimize the physical, emotional, and cognitive efforts required by a visitor to navigate through the space. This off-loading of required resources allows the visitor to be able to direct more attention to the content, making it more accessible and easier to consume.

Another means to make exhibition content easier to understand is by providing interpretive labels that utilize layers or levels of information to support a well conceived, cohesive exhibit plan as suggested by Serrell (1996). Writing clear labels of all types - title, introductory, object labels - play a vital role in telling the topic underlying an exhibition and helping visitors connect with science. Participant 4 described how integral labels are to the accessibility of content:

> I think that in terms of content, no matter what the content is… we try to make it accessible. It has to be simple and inviting. We encourage our visitor to read the text. It's a reminder posted through our galleries.

As evidenced by participant 4, labels should be clear - both in terms of the information they convey and the way they are written. With regard to creating labels for an exhibition, the length, type size, style, format and vocabulary should be addressed and lead to curiosity as suggested by participant 5. His comments suggested producing the right text can lead to interest and wonder in science centre visits (comment 31). According to participant 7, in terms of the experiential learning, the Questacon realized the need to offer additional support and assistance to encourage making connections through different styles of exhibits:

> There are different styles of exhibits that we would prefer as educational/learning experiences or the informal learning approach. The style of exhibit that we would prefer varies such as problem solving exhibit, information communication, exploring physical phenomena; open ended, play form, experimental style and quizzes. There are a lot of exhibit styles we can come up with, depending on whether that topic is

> important for that particular style of exhibit. Together, the Exhibition Project Team will try and pull them up together.

As she suggested, some connections may be preferable depending on the topics for different style of exhibits. For subtler connections, visitors may need a little variety and support to access the connections. The Wonder Works gallery provides content in such a way that visitors have fun while exploring science. For example, building a life-sized disordered room provides immersive experience. Offering these types of tactile, sensory experiences makes science more readily accessible, since there are multiple levels on which to interact with the content. As commented by participant 1:

> We do exhibits such as the Ames Room, the disordered room. We create that space to have an impact on them. We go that extra trouble, a lot more effort to get the full body experience. Yes, set work and space is the understanding for the exhibits. It allows one to enter and physically immerse in the room to understand the phenomena - rather than reading labels of a scale model.

His quote indicates that one key design objective for the gallery was to help visitors access the content. Instilling a sense of relevance can reinforce the creation of connections. However, there are limitations of science centre experience, as commented by participant 8:

> Experiments in a public setting can only deal with certain phenomena. If they are too big or too small, too fast or too slow, they have to be replaced by simulations. In some cases narratives or historical objects provide a better approach.

As he mentioned, connections through science experiments have its own constrain and limitation. Therefore, other methods such as simulation technology, narratives or historical objects can be a more suitable approach.

4.4.3.3 Providing Relevance by Drawing on Social Environment

Everyone has a preference - grounded in one's cultural value and own personal experiences. Incorporating exhibits, information, and issues within the science centre exhibitions that reflect on visitor's lives or social environment can help cultivate connections. The variety of issues and facts in the exhibition provides many instances for visitors to find connections to their own lives. Participant 2 described some visitors he observed making personal connections with the objects and exhibits in the exhibitions:

> [People] find this personal connection in some facet of the exhibition… It can be random, it can be as simple as the chicken hatch and they're like, "we used to watch this every time when we visit the place." That kind of stuff. I always find that interesting. Walking through and overhearing, or when I see parents telling their kids stories about, "when we grew up" looking at the gravity ball and kind of telling stories and how they were observing them back then.

As he expressed, people get excited when they see things that reminded them of objects or memories from their own lives. Not only does seeing something familiar catch a visitor's attention, it also reinforces memories and makes the visitor more likely to share their memories and personal history with others - passing along a bit of connection. When visitors find themselves drawn in by something familiar they are also apt to look more closely at the other exhibition components and content, thereby connecting themselves even further with the place.

Offering ways for visitors to relate to the exhibition content or context is important. Participant 2 described several examples of areas in the science show which pique visitor interest. As his comments suggested, presenting things people will recognize is an ideal way to attract visitors to look more closely at an exhibition (comment 32). Familiarity offers the perfect hook for the centre to pose more detailed information and help visitors learn new things that will broaden both their knowledge and deepen their personal connection with the content and science wonders. Objects can play a powerful role in communicating science in the exhibition. The size, placement, and general science discovery of an object can factor into the initial impression a subject has on a visitor. Sometimes the most important impact of an object is tied directly to a personal connection a visitor already associates with. Participant 4 described an example:

> I saw a great thing happen in a [planet] gallery, with students who had explore the interactive exhibits and knew the rotatable link tunnel that's on display there, they go through it a few times…So it was the experience that people can really connect with …when people really get involved in objects, I think that has a huge impact on them.

As her description indicates, a pre-existing personal experience with an object can lead to exploration of the object label, as well as promote further involvement with the surrounding objects and other components on display in the exhibition.

Even if visitors do not have a personal connection with a specific object, they often find themselves drawn to certain exhibits based upon aspects related to their personal interests and experiences. They may see objects and be reminded of science fictions they had read from books. People seek out connections based on their life and personal experiences, as explained by participant 9. As he described, personal details can prompt visitors to make connections (comments 33). Helping visitors connect with exhibitions on a personal level can trigger questions; asking questions can lead to gathering new information; new information can result in having visitors leave the exhibition with a new personal connection with science. It's the immersive experience itself.

4.4.3.4 Creating Interest by Engaging with the Exhibits

Sometimes unearthing new discovery can pave the way to engaging with science, creating new interest, and introducing new ideas and connections. 'Invent', described participant 2, exemplifies an exhibition which provides visitors the opportunity to create new awareness and find new connections by building on familiar context. As his comments suggest, 'Invent' and the scenes displayed within it carry a sense of layering message not just in terms of content, but because of being on display as a market stage (comment 34). Visitors who came to the gallery for the first time will likely remember the elaborate recreations of these 'streetwalk' events. The interpretive labels and interactive components placed alongside the multimedia encourage visitors to look more closely and see new details in the content presented before them. The interactive components challenge visitors to use more than just their eyes to gain a deeper understanding of the issue depicted. Visitors have the opportunity to do something - to push buttons, to play music, to click the camera - to interact with the exhibits. Interacting with an exhibition on multiple sensory levels can add depth to a visitor's experience. The technology's gallery, 'How Things Work', was designed and developed specifically with the intent to engage a full range of sensory experiences and elicit connections with science application, as explained by participant 4. As she indicated, 'How Things Work' engages visitors by providing the opportunity to do something related to science application - helping visitors connect with the concept (comment 34). She also noted how the hands-on nature and the varieties of exhibits stations contributed to the success of these exhibitions with school groups:

> They are having fun…I think [they are] surprised that this type of space is here; they're doing something other than looking. So, I feel the school group visits are highly successful…we're contributing to their learning and understanding of it.

Her statements propose that by having the opportunity to interact with the exhibitions students are creating foundations for future connections and learning. Likewise, being able to relate something from one's previous knowledge with something in the exhibition can result in the formation of new knowledge and understanding. Interaction with an exhibition can lead to excitement, new knowledge and connections. People get excited when they feel like they are part of it, especially when it involves interacting with an actual object, explained participant 7:

> Excite@Q was great because it makes you do every single aspect of it. People love that. They like to be part of it... like the freefall and 360', which people love because they can feel through it, that's a bonus. It's the very first freefall design to explain its connections to the psychological science. It lets them to actually experience a fright and excite feeling, biological feel, that's so integral to our mind and body. I think experiencing the real stuff and having it being engaged in some way, is worthwhile.

As the comments implied, if a visitor can feel a real piece of science - can be part of it - then the experience becomes more tangible, more personal and heightens the connection to the theory behind it. Getting beyond the surface of the exhibition - delving into the context and the concept that the exhibition reflects - is the important part of making a lasting personal connection with science.

Participant 1 conveyed some examples of exhibits and objects at the Questacon which attempt to engage visitors' senses and gain a deeper understanding and connection with the role of science in their lives (comment 36). The examples he shared exemplify how the Questacon juxtaposes current objects and stories that relate to contemporary life - of science in the environment - bring a sense of relevance to the toddlers. Providing young visitors the opportunity to be directly involved with an exhibit and make a personal connection between the exhibit and their own lives can lay the groundwork for learning. These informal learning tool has its benefits, as commented by Participant 8. The opportunity to be directly involved with an exhibit and solve a task has its intellectual and emotional benefits (comment 37). Likewise, learning can be difficult to access in an exhibition setting, since it is not a structured learning environment and because visitors may not recall their visit experiences. Some may not even realize what they have learned until long after their visit. Participant 7, described learning from an exhibition in this way:

> Science centre immersive exhibit play with your senses. So, sometimes the immersive that we have is an experience that will 'upset' your sense of balance a bit or it create a particular perception, a response. For science centre, an immersive has an impact on you. Immersive is - 'I am trying to change your senses' as the message.

As she described and echoed by all the participants, learning is not necessarily the targeted goal of an exhibit, but it can be a by-product of the experience. Rather than focusing on learning as an outcome, the Questacon strives to offer visitors stimulating experiences that will create personal connections which make enough of an impression to stay with visitors long after they leave the centre. Visitors are given an invitation to open their eyes to science and see the connections through aesthetic space. As stated by Participant 4:

> Providing a lovely connection to the Bonifacio Art city…hoping when visitors leave, they're looking at the city in a different way. That we've provided them with fresh eyes to both art and science, as they move through the city, make new connections with artistic works outdoor and aesthetic theme of science indoor.

Helping visitors leave with new connections, as she described, relies upon knowing who its visitors are and understanding why they came. This section focused on the need to craft a collaborative vision by means of the approach to the exhibition design process and the personal connections formed with people, the institutions and resources outside the centre. The interview participants' responses highlighted that science centre do encourages visitors to find connections by means of making science accessible, providing relevance through personal engagement and creating new memories by engaging with the exhibits and multiple contexts of the museum experience.

4.4.4 Designing Inclusive/Immersive experience

The fourth theme, designing inclusive/immersive experience, focuses around the concept of the science centre's need to accommodate for diverse visitor values, interests, motivations, and learning processes. Conscientious design might foster changes in visitor attitudes, knowledge, belief structures and curiosity. Such insights may be applicable to support informal learning and visitor diversity. The biggest challenge for a science centre institutions is to strategically provide opportunities for cognitive and affective learning while simultaneously facilitating enjoyment and fun. The subsequent discussion addresses a variety of findings relative to the following perspectives pertaining to quality visitor experience: (1) Targeting a range of audiences; (2) Broadening the range of exhibition appeal; (3) Providing family friendly experiences; (4) Establishing an inclusive science centre environment.

4.4.4.1 Targeting a Range of Audiences

Science centre recognize that knowing their target audience is critical to effectively conveying information. It is important to accommodate new and different visitors in the exhibition planning process. Participant 1discussed how this accommodation is reflected:

> We never know who may come through the doors so our aim is to produce exhibits for anyone although we do identify the target age range in the concept development process. Of course this has many challenges. We can provide for differences in age, physical size, learning preferences, by developing a diversity of experiences.

He further elaborate on identifying and understanding the needs of their visitors is the starting point to designing successful exhibitions (comment 38). Similarly, as part of the ongoing process, Science Centre Singapore made it a goal to target a wider range of audience segments, as identified by Participant 2:

> We had few different audience segments we were specifically targeting and we had to keep all of those in mind as we talked about it so it would appeal to everybody. We're expanding our core audience from school groups to families.

Since the scope of audiences for the SCS has expanded from the core segments as described, the centre's effort to connect with these new visitor groups has expanded as well. The next section explores some considerations and efforts the science centres made to reach out and promote connections with these audience segments.

4.4.4.2 Broadening the Range of Exhibition Appeal

As apparent from the targeted audience segments, most science centre is trying to reach a broad range of audiences. A core similarity across these audience sectors is that they are primarily part of the general public. Participant 1commented on addressing visitor experience in the exhibition design process:

> As the designers are not scientists they can act as audience advocates – if the designer does not understand a presented concept can we assume the general public will? The designers can visualise an experience and 'walk in the shoes' or 'see through the eyes' of the visitor. A vast array of parameters are considered when designing experiences for visitors including ergonomics, accessibility, circulation, atmosphere and environment, content and interaction, diversity of experiences.

He highlighted that understanding the presented concept is important in the exhibition design process. It is worthy to be aware that even though the centre and staff may have scholarly notions and ideas they wish to convey through their exhibitions, visitors may approach the experience from a more informal perspective. The staff needs to be conscious of what people hope to get out of their visit. Participant 4 described the strategies to provide an experience:

> The Mind Museum started with the idea of storytelling. I am a scientist and a writer, design this way seemed natural. It’s a narrative space…The science theme relates big and small matters in the four main galleries – Universe, Earth, Life and Atom.

According to her, the strategy to provide an experience can be adapted from storytelling. This is one way to communicate the relation of matters in science centre. Connections through various experiences are becoming a trend. Nowadays, science centres have stolen concepts from other cultural institutions in a way to reach more audiences, as explained by participant 3. He suggested that the gesamt idea of merging cultural institutions concept is new in science centre field (comment 39). It could be developed to attract more people to visit and connect with a range of appeals. Visitors from the general public may share some commonalities; however, they have much dissimilarity as well. Thus, it is necessary to understand what draws different audience segments and their specific needs and interests. Participant 2 described some older core visitors appeared to be more set in their interests and younger adult visitors were more reachable and open-minded. He went on to describe the younger adult audience segment as excited and interested in connecting with new aspects of science and learning about themselves and the global issues of the environment (comment 40). He indicated that given the potential draw of this younger audience segment, the SCS made a deliberate effort to infuse their exhibitions with topics and design elements that might appeal to younger, prospective visitors. He further explained how SCS tries to attract a younger crowd. As participant 2 expressed, although perhaps not always successful in all instances, SCS aims to attract different audience segments by rotating the exhibitions on display (comment 41). Developing new exhibitions also allows the opportunity to explore new methods and techniques in exhibition and exhibit design, as commented by Participant 1. He agreed that in developing new exhibitions, there are benefits in promoting new techniques to engage audiences and encourage return visitation (comment 42). Participant 4 described on making the scientific issue more 'experienceable':

> We usually see science centre associate with technology to make exhibits interactive. Mind Museum is a museum with artistic mould; you can see it flow from the main entrance welcoming visitors. It is also along the edges and corners, sculpture in space; the vibrant colours; Use of LED lighting with a difference especially in the universe gallery. It is an immersive environment.

According to her, artistic design can immerse science experience as much as integrating technology for interactive exhibits. Participant 3 commented on design for social situation as a tool to reach a broad range of audiences. As he reflected, sociality and nurturing is deliberately designed in science centre to satisfy the visitor's emotions and pleasure of mind (comment 43). The SCS varies its temporary exhibitions to try to connect with particular target audience groups. Participant 2 reflected on the change in the use of temporary exhibitions to reach specific audiences. According to him, since the permanent exhibitions are now designed in a style which appeals to a wide range of visitors, SCS can use their temporary exhibitions to add depth and specificity to the topics the science centre focus on (comment 44). The exhibitions reflect a cross-section of experiences and interests representative of the full range of the SCS's target audiences. Each audience segment has its own set of characteristics and needs.

Variety in exhibits can ultimately help reach different visitors and attract them to the centre, explained participant 2 at SCS. As he suggested, different visitors respond to the different kinds of exhibitions (comment 45). Identifying which audiences the centre wants to reach and deciding to broaden the exhibition scope to appeal to those audience segments is the first step in drawing new visitors. Creating quality exhibitions is a challenge. In particular, defining and reaching the family audience posed a prolong challenge, since SCS had always placed a focus on that audience segment. Constant efforts were made to always reach out.

4.4.4.3 Providing Family Friendly Experiences

Families are one of the primary audience segments most science centres hoped to draw with the exhibitions. Participant 1 at Questacon explained how the exhibits throughout were prefaced with extensive research and planning in order to define, to understand, and to address children and families as a broader audience segment (comment 46). Participant 7 further explained how the team tries to accommodate younger crowds (comment 47). As both participants expressed, reaching family units was at the heart of the exhibitions. In order to do so, the design team conducted research and focus groups to get into the minds of children and family groups to determine how to best reach them on multiple levels. The team sought to understand ways to weave physical, visual and science connections into a social museum experience for children and family groups. Equipped with feedback and information about the reaction of children, Questacon Technology Learning Centre (QTLC) also design and install kid-friendly, family-friendly exhibitions with a focus, stated participant 1. According to him, including permanent exhibitions designed toward a profile that matches with a younger audience subset would likely draw children and families, but not necessarily be limited to that particular audience segment (comment 48). Many aspects of exhibitions which appeal to children are the components which make a science centre experience fun. Adult visitors even those who are not part of a family group, like to be entertained during a visit. Fun should be part of a museum experience, stated Participant 7:

> People need to come here and they have fun. They're spending their time, their free time with their families, to come here and learn in a fun way. And I think that it has to be the number one goal. I think that's why, Questacon is successful…there's a good time.

As she expressed, visitors should enjoy their time at the science centre. When people are enjoying their visit by interacting with the exhibition and each other, it strengthens all the connections they are making - emotional connections with the scientific content, intellectual connections with their existing knowledge set, and social connections with the others in their group and other visitors. Participant 4 also described how important having fun is to the visitors and to the overall atmosphere (comment 49).

As evidenced by her comments and echoed by others during the interviews, the science centre is infused with energy due to the designed hands-on exhibitions which provide visitors the opportunity to laugh and enjoy themselves at the centre. Fun may be a key to bringing some audience segments through the door, but it may not be the key to reaching all the audience segments, and it certainly is not the only component of a museum experience that matters to visitors. Adding depth and variety to not only the scope, but the voice of the exhibitions is a component to establishing an inclusive museum environment and offering connections to science for the full range of target science centre audiences.

4.4.4.4 Establishing an Inclusive Science Centre Environment

Wanting to connect with a wider range of audiences is a worthy notion; actually doing it is a challenging task. Most renowned science centre is certainly making the effort and is likely to succeed. This sub-section explores specific examples of progress the science centre is making to open its doors to new visitor and modify its exhibition design and programs to be more representative and inclusive of new visitor subsets. Participant 2 stressed the importance of conveying a sense of multiplicity through variety:

> I think there's a message that's sent when you have different approaches, and you have different voices - both within a particular exhibit but also within the centre as a whole…people come in and there's a lot they can do.

As suggested by him, different topics, different approaches, and different perspectives - breadth in all these respects serves not only to offer variety in the type of exhibition, but sends a message to visitors about the value the SCS places on supporting different preferences. How the centre addresses its range of visitors can be as important as the information selected to share with them. Language, vocabulary, tone, content, and voice - they all contribute to how visitors will interpret and potentially be moved by science. As described by Participant 4, minimizing the tone of academic superiority in exhibition content can help visitors be more receptive and feel empowered by the information presented to them (comment 50).

She indicates an audience focus is implemented in The Mind Museum in varying degrees depending on the exhibition or program, but it is an underlying focus for all materials designed for public interaction. Programs offered by the museum can be as important as exhibitions in terms of broadening the museum's audience base and reaching new visitors. According to participant 7, creating programs to reach diverse audiences is a goal for the Questacon (comment 51). Even if involvement in programming does not result in more visitors walking through the doors, offering a variety of programs is likely to encourage interest and connections with science and Questacon. The Questacon has some ongoing programs, including the "travelling exhibition" program geared toward the far away community, which exemplify inclusion and celebrate the diverse children of Australia. Programming can connect new communities with Questacon by acknowledging these communities interest. As participant 7 suggested, every subset of the population should be inclusive through science programs and travelling exhibition tour in Australia (comment 52).

Finding ways to help not just one visitor, but a wide range of visitors, make connections is often rooted in generating some kind of emotional interest through their museum experience, described participant 4. The concern for audience and reaching them emotionally must come first (comment 53). If they are not interested, nothing they see around them will make an impact or generate a connection. Participant 9 explained the importance and the challenge, of designing in anticipation of the visitor's needs:

> The greatest challenge to any designer is to be able to anticipate the needs of a visitor, understand the content and then to create an experience in the space that allows the visitor to bring their knowledge, their passion, their interests, their curiosity to bear on the project in a comfortable, meaningful, satisfying way.

As he indicted, the connection a visitor makes in an exhibition is more than about tailoring the content to meet visitor needs. The topic or objects in the exhibition may spark interest or help generate an initial emotional response, but the entire exhibition design and all the elements used to create the exhibition environment must be considered relative to the target audience in order to maximize the visitor connections.

4.4.5 Balancing the Constraints

The findings from the rich and descriptive qualitative data gathered during interviews deal with recognizing the challenges in maintaining a sense of overall equilibrium in science centre. The final theme, balancing the constraints, explores the complexity of merging ideas, reaching a compromise when allocating resources and blending exhibition design approaches to enhance visitor experience. Negotiating resources requires careful consideration and balanced distribution based on the scope and importance of projects the science centre has planned. Available budget, time and space needs drive decisions in the exhibition process and can force changes or concessions in the exhibition design and fabrication.

Making exhibition design decisions involves attention to the project as a whole, as well as the individual exhibition elements. Much of what does or does not come to fruition during the exhibition planning process at the science centre is dependent upon the resources available. Priorities must be established and implemented based on available resources. There are many issues, realities, and perceptions that impact the design of new science centre exhibitions. Participant 1 shared his view:

> There seems to be a perception in visitors that they can do anything in an interactive science centre. Together with WHS legislation this impacts the concept, the design process, the budget and the final exhibit produced. Exhibits that do not satisfy the Risk Assessment process will not make it to the floor. Changes in Government priorities impact the focus of exhibition topics.

He highlighted legislation procedures, risk assessment process and changes in government priorities give impacts to the concept, design process, budget and the final exhibit produced. Aside from all the issues coming from different perspectives, Questacon practice certain methods in order to balance the distribution of exhibition resources. During the routine exhibition design projects, the allocation of resources play a critical role. Balancing resources through careful planning effect design decisions made throughout the exhibition process:

> At the beginning of each year Questacon assesses the condition of our existing permanent galleries, travelling exhibitions and outdoor exhibits and rates them against a range of criteria. The Exhibition Condition Index (ECI) provides the plan as to when our exhibitions need to be disposed of, replaced or upgraded. The criteria include relevance, sustainability, venue demand and presentability.

He highlighted the annual assessment of existing exhibitions is the initial step during the evaluation process. New exhibition topics will depend on distribution of exhibition resources in terms of time and budget (comment 54). Next, the different teams with various education and design backgrounds continues with the communication, education, preliminary design and conceptual testing for the development of new exhibition proposals:

> The Concepts team (part of another section – Questacon National Programmes and Learning Experience, LEX) undertakes the necessary research and sets the communication and education outcomes. They also prepare briefs for each of the proposed exhibits and the exhibition as a whole. This includes preliminary design work in the form of sketches. The Concepts team members have Science Communication backgrounds so are best able to undertake the appropriate research and provide accurate science and educational material.

Conceptual phase is further develop into 2D and 3D design where the visitor experience is resolved through various technical and design solutions (comment 55).

The fabrication of exhibit mechanisms by the Production team will further develop electrical requirements and programming computer interactives based on available resources (comment 56). As indicated by participant 1, working through the exhibition process and creating exhibitions requires a fluid process which seeks a balance among many factors and elements. Available funds and the project budget are frequently major factors in the science centre exhibition projects, both large and small. The following findings addresses how the science centre strives to balance distribution of exhibition resources in terms of: (1) budget, (2) time, and (3) space.

4.4.5.1 Budget

Under ideal circumstances, a science centre would not be restricted in the potential scope or creativity of their exhibition projects due to lack of funding. Unfortunately, in reality, money does drive exhibition decisions. This findings explores how funding impacts exhibitions at the centre in terms of concessions and limitations due to resource shortages such as how the budget and fundraising determine what can be included in exhibitions. Participant 1 expressed Questacon concerns over the matter (comment 57). As his comments suggested, reduction in funding increases admission costs and give impact on visitor expectation. This add pressure on balancing limited resources. The design and development processes of exhibitions also depends on the size of the science centre, as highlighted by participant 5:

> A small science centre that employs less than 20 people struggles to make operational ends meet. They rely heavily on volunteers and local fund raising and can bring on generally a few new exhibits in a year. Such centres are driven by an enthusiast – often the CEO or the Chair of the Board.

The image and the opportunities science centre provides, drive the amount and types of funding the centre is able to bring in through grants, donors and government support. Participant 5 commented on the science centre operational budget and financial assistance. As he mentioned, the substantial backing is a challenge faced by many science centres. The government support and private funding does influence the success of the development process (comment 58).

When overall resources are limited - staff, time, and funds are spread thin - there can be strain on the creative aspects of the exhibition process, as participant 1 explained (comment 59). He also acknowledged the pressure to maintain in developing new exhibitions with higher visitor expectations is pertaining to increasing admission costs:

> For reasons of maintaining visitor numbers in light of increasing admission costs there is pressure to deliver exhibitions that continually improve on previous offerings. Increasing costs of materials and services, increasing Workplace Health and Safety and other requirements together with reducing budgets all have an impact on what can actually be delivered.

In terms of balancing resources across projects, deciding how much money should be allocated to different science exhibitions and programs is difficult. Making budget decisions must also take into account the need for the science centre to fund projects which will draw interest and external support, as explained by participant 5 (comment 60). External and internal factors influence the delivery of exhibitions. Considerations comes from the Government, organization, reducing number of staff expertise and losing corporate knowledge are some of the issues, as mentioned by participant 1.

> Changes in Government requirements and processes, organisational change and restructuring, diminishing staff and expertise, corporate knowledge walking out of the door as staff leave all impact on the delivery of exhibitions.

The process for deciding an exhibition is varied too. Though it might be preferable for a science centre to be able to make decisions based strictly on internal considerations and vision, external factors often weigh into the process when it comes to funding. The centre needs to make choices related to the content and type of exhibitions it displays, at least in part, based on acquiring funds and support for the project, explained participant 5 (comment 61). The sponsor support and inclination for the project, Snowdon noted, can be a factor that impact the choices related to the content and type of exhibitions it displays. Although the bigger institutions do often get funding that can be deployed internally and unencumbered i.e. without interference from non-experts, it is frequently a case that interferences can happen internally. Participant 5 comments:

> The internal committee can have representatives from a variety of departments – exhibits and design, marketing, finance, education and these people have agendas to watch over. This can lead to conflict internally. For example, industrial designers can design the physical look and propose where an how the graphics, the texts, the photos, the layout. The fonts, the colours should be only to find their work challenged by wordsmiths from Education or font, colours and logo placements challenged by Marketing. So, the processes involved can depend on many factors.

Participant 1 also commented on the similar issues (comment 62). The exhibition topics, programming options, and day-to-day happenings at the centre combine to project the creditability of a science centre. Producing a robust quality exhibit is important. They are quite expensive and involves much expertise in meeting the criteria for quality exhibits, as explained Participant 5 (comment 63). Many models have been used in developing exhibits in science centres. He highlighted the common practice developed in some region (comment 64).

In summary, these findings looked at how budget limitations and funding must be addressed and offset during the exhibition process, how funds determine what is or is not included in exhibitions, and the need to design exhibitions and offer programs which will draw return and benefit. When external contractors are utilized in the exhibition process, the budget and the timeline often are more difficult to control, than if everything is handled internally. Similarly, securing external funding requires closer monitoring of project timelines. Balancing the expenditure of time throughout the exhibition process is as important as balancing the flow of money.

4.4.5.2 Time

Time can be as valuable as money when it comes to planning an exhibition at the science centre. Whether planning for a large or small exhibition, establishing a timeline and staying on schedule is critical to timely completion. This sub-section presents time as a pertinent resource in the exhibition process by addressing: long term scheduling and project management issues; coordinating the timing and decisions necessary for specific exhibitions; and competition for resources due to timeframe limitations.

Time is measured in different ways by different people, depending on their perspective or involvement in the exhibition design process. The people who set the exhibition calendar or schedule may not always have the same frame of reference as those who are meant to carry out the schedule. This disconnect can create ripples in the expected time continuum. As participant 1 explained, many exhibit concepts and scheduling decisions are made from the top down (comment 65). He stressed that when exhibition decisions regarding time are made and passed down from top management, managing an exhibition project requires close attention to the time schedule. This is in addition to careful coordination of all the people and components involved in the process. One of the biggest challenges according to participant 4, was keeping everything moving along in a timely fashion:

> There were a lot of people, if you can imagine, that had to be informed, involved, approve, review, a lot of this stuff and then there was a schedule. I think that was really the toughest thing, was being able to manage the people that had decision-making power, making it in a timely fashion.

She shared that staying on schedule is easier to achieve if project considerations - such as timeline, budget, and resources - are clearly identified and communicated to the project team. Well-coordinated project oversight plays a major role in the efficiency with which an exhibition reaches completion. One of the biggest time related challenges described by staff at the SCS was having to work within a compressed development timeframe.

Time limitations bring added stress and pressure. Participant 2 described the SCS as constantly improving to establish a more balanced exhibition schedules - by allowing more time for idea development upfront, without putting undue pressure on the production end. Planning exhibitions further in advance would provide a longer development time and a less condensed schedule for completion. He shared his comments about the need for a more concrete, yet forward-looking exhibition development and production schedule. He indicated that keeping the exhibition timeline moving along to stay on schedule for the next exhibition opening is a constant struggle (comment 66). If one part of the schedule falls behind, it triggers a ripple effect impacting every subsequent aspect of the process. The staff must continually balance the time needed upfront to develop ideas against the time required to fabricate those ideas into a tangible exhibition, while taking into account all the steps in between.

As he expressed, unfortunately, there are limitations to what can be done with limited time and resources. Even with talented and creative individuals pooling their time and efforts, working under tight deadlines on a regular basis is stressful and can lead staff to be frustrated with the exhibition planning process. In summary, these findings addressed some of the challenges science centre encountered in terms of planning and scheduling exhibitions. Overall project management and long-term exhibition scheduling, as well as the timing and decisions for individual exhibitions, are important. Competition for limited resources can be worsen when the timeframe for completing a project is compressed. Limitations in time and other resources often results in the need for exchange or compromise to be made in the exhibition plans. All resources related to an exhibition must be carefully balanced. Besides funding and time, space is another primary resource which requires consideration and attention in exhibitions.

4.4.5.3 Space

Just as cost and time are negotiated resources in the exhibition process, so is space. Exhibitions are bounded by space - by the overall size of the centre, by the layout of the gallery, and by the quantity and specific dimensions of the elements intended to fill the available exhibition space. This sub-section presents restrictions and limitations encountered in the exhibition process as related to space. Designing an exhibition requires managing the physical gallery space and balancing the unchangeable, predetermined factors that come with a space. For example, participant 2 noted the need to consider and accommodate for structural aspects of a gallery space:

> There's always the challenge of just your physical space. Using your physical space and where your support structures are and columns you need to work around and all of that. I think that's a big challenge.

As he indicated, structural aspects or physical limitations with a gallery space can pose challenges and require aligning or reworking an exhibition design accordingly. He explained that many decisions related to the exhibition design in SCS were driven by the physical layout and space in the exhibition gallery (comment 67). Beyond design considerations regarding pre-set, the unchangeable factors of the overall space require the design process to decide and determine exactly how the exhibition space will be configured. Every detail of the space must be considered and factored into the design. Designing an exhibition is a labour intensive and collaborative effort, explained participant 4 (comment 68).

As she noted and also discussed in the previous chapter, the interaction between all the exhibition elements is critical to the formation of the exhibition as a whole. The design, exhibit selection, and the space are inherently connected. On some levels the design and objects form the space, yet the space also drives the design and dictates the objects which can be included. There is not always a clearly defined design solution at the start of a project - the exhibition unfolds, taking on form as specific issues are resolved throughout the process. Participant 2 explained how it was a struggle to determine the details and figure out how to make the design work within the physical space (comment 69). The design of an exhibition requires a fluid process which seeks a balance among many factors and elements. Based on these interviews, space limitation, not enough time and not enough money are the limitations which make an exhibition process a struggle. Allocating available resources is as much of a challenge, as it is in the initial design and development of exhibitions.

4.5 FINDINGS AND DISCUSSIONS

This next section presents summary of findings and discussions in understanding the interpretation of the experience offered by science centre. This is reviewed in light of the three research objectives, namely: (1) The tools for enchantment of the science centre; (2) The interconnection between its representational systems and the tools for enchantment; (3) The design opportunities that will improve science centre visitor experience. The discussions is concluded by reflections on the research findings.

4.5.1 Tools for Enchantment of the Science Centre Experience

The relationships between science centre offerings, design emphases and visitor experiences are addressed for better understanding of experiential design in science centres. The literature and observations in the contemporary culture suggest that experience has become a focal offering in the market (e.g. Pine and Gilmore 1999). Consequently, investigating experience related issues is gaining bigger importance in order to have a better grasp of many successful science centre strategies. Specifically, understanding the characteristics of certain tools for enchantment of the science centre experience that visitors find significant is important for creating encounters that are substantial and successful. Following on the suggestion by Goulding, (1999) and Falk and Dierking, (2000), edutainment experiences are presented in the literature as a hybridization resulting from the ability of science centre to combine their original function of transmitting information (educational dimension) with their ability to engage the visitor in the heart of the exhibition through playfulness. Hybridization of these cultural experiences emerges from the analysis of the science centres. The willingness of managers to enrich the cultural offer leads to modification of the contents with the combined presence of spectacular, immersive, ritualized and commercial dimensions as suggested by (Gottdiener 1997; Sherry 1998; Penaloza 1999; Ritzer 2005). The discussion of findings from the observation suggests that design emphasis increases in complexity to overwhelm, stimulate, and transform, resulting in greater emotional impact that uplifts the level of visitor perception from mere acceptance to motivation and enjoyable learning experience. Science centre promise the visitor to live a rich and stimulating experience both in time and space.

4.5.2 Interconnection between Representational Systems in Science Centres and the Tools for Enchantment

Exhibition design is a synthesis of the functional, sensorial and meaning-oriented aspects for staging meaningful visitor experiences. Research findings confirm that science centres are designed to support learning experiences where visitors construct personal meaning about the world around them as suggested by Falk & Dierking (2000). Designing for experience requires a deep understanding about meanings relevant to its visitors. Since experiential offerings communicate meanings through many functional and sensorial means, they usually evoke memorable experiences for science centre visitors.

Ideally, science centres try to achieve excellence by designing science phenomena through experiential offerings. Research findings suggests that these meanings are communicated through science centre representational expressive modes of visual representations, three dimensional representations and degree of linearity. Considering science centre as ‘texts’ that employ a variety of semiotic modes for constructing their own messages, the main functions of these messages refer to (1) the degree of the techno-scientific content specialization, (2) the degree of specialization of the corresponding expressive codes as well as (3) the interpersonal/affective relationships that tend to be established with their potential visitors.

The findings of this research hint at the possibility that designed features in science centres also act as message. This is because visitor not only pay attention to atmospherics per se, but also take them as cues to interpret the science centre's intent. This intangible aspect embodied in science centre play a role in visitor's participation and immersion. An understanding of how visitor interpret meaning in science centre and how those interpretations influence their perceptions and participation will be beneficial for designing science centre exhibitions.

The messages being communicate from science centres in this research, focus only on three dimensional aspects, lighting quality and degree of linearity of representational modes. The classification, formality and framing theory of representational modes were used to describe the access that the exhibitions offer. This is to clarify the relationships between the types of science centre offerings, design emphases and impact on visitor participation. The findings show how design can influence visitor participation through modulation of experiences with different emphases on:

i. Three dimensional representations - Functions and forms, colour differentiation, colour modulation, parts of the objects represented, texture, vertical angle of view, size, horizontal angle of view and minimum distance of approach.

ii. Lighting quality - Degree of colours realism, colour differentiation, degree of directionality and intensity of lighting with respect to the surroundings.

iii. Degree of linearity - Reference to other exhibits, proximity and connective elements.

This understanding is of value for both science centres and designers as it facilitates structured attempts to design for quality science centre experiences. Visitor interpret the representational modes expressed by science centres from features that show quality of offerings, as well as flexibility or choices of exhibition features. Well-considered and well-designed exhibition details evoke direct participation as those details are evidence that the science centre has offer transformational experiences for visitors. To summarize, there is a relational dimension when visitor perceive design in the science centre context. Visitor participate according to the interpersonal/affective relationships offered by science centres.

4.5.3 To Identify Design Opportunities That Will Improve Science Centre Visitor Experience

This section highlights the conclusions from the analysis regarding design opportunities for improving visitor experiences. Improvements of science centre offerings for enhancement of visitor experiences should focus on matching design concerns. These are explained from the curatorial and managerial perspectives. Design opportunities that enhance visitor experiences are discussed in five themes: Invoking interest, delivering the message, connecting personally, designing inclusive/immersive experience and balancing the constraints.

i. Invoking interest

The first theme, invoking interest, bridges together a variety of factors which relate to the science centre as an institution and what the centre aims to convey to its visitors and the public at large. The theme focuses on the centre's efforts to create an identity for the science centre; allowing for interest, curiosity and variety; reframing content with a different lens; providing wonder and surprise; allowing for dramatic effects and dealing with current issues affecting the global community. The case studies offer multiple levels on which visitors can make connections with the varieties of subject range in addition to the interdisciplinary approach to exhibition themes. The finding is coherent with the findings by Falk and Dierking (2000) which indicate the importance of the "whole experience" for visitors through their Contextual Model of Learning in museums. The personal background of a visitor intersects with multiple contexts of the museum experience to impact the visitor. Findings from the current study indicate that efforts to provide visitors with a "whole experience" are rooted in carefully compiling the complex parts of the design process to create an effective whole exhibition.

Science centre strives to convey science concepts, issues and its related technology in application to human life and the environment. The importance and the challenge of designing in anticipation of the visitor's needs are to be able to anticipate visitor interest. Careful attention is given to how the exhibition design elements and physical space are combined and presented to create an appealing, inclusive, multi-layered visitor experience. Aligning the internal sense of character or identity of the centre with a corresponding external image is notable as an institution. Science centre building should have unique criteria such as a city landmark. In broad perspective science centres have many similarities, but they differentiate themselves by the way they are organized, the people who contribute to them and the focus the centre chooses to put forth. Interview data analysis revealed that the exhibition design and development process at the science centre involves many individual people, ideas, and components that must work together as a unified whole. Those who work in a science centre make decisions about how the centre will place value on projects and ideas. By that, the management is critical in creating the centre's sense of identity.

There is a need for the right technique in facilitating an experience to inspire learning in science centre. In designing an exhibit that will inspire interest and curiosity, processing fluency is the key to attract and fascinate science concepts. Processing fluency is a design tool to benefit visitor psychological behaviour in approaching hands-on exhibits. There is also a need to challenge one's mind as the flow theory recommended. Flow theory is to facilitate curiosity and virtuosity in designing visitor experience. It is important that science centres provide cognitive understanding in delivering the message. Emotional understanding comes from positive evaluation that happened in many stages. These stages of translation in cognitive understanding lead towards the meaning making in exhibition experience. Furthermore, a successful experience needs to involve all four realms: educational experiences, entertaining experiences, aesthetic experiences and escapist experiences.

The importance of aesthetic and escapist experience is to be in balance with entertaining and learning experience in a science centre. Some of the exhibition concepts practised have design towards escapist experiences that has an element of wonder, surprise and allowing for dramatic effects. Science centre needs to show its exceptional wonder and unexpected intense - and emphasized that those things are at the core of the centres attraction. In order for these transactions to occur, designers and developers must be conscientious about exhibition design. It is important to be intentional. Spectacular design can help those exhibitions that are intended to immerse audiences into a story, give them the opportunity to witness a different world, engage them in hands-on activities and have a lasting impact. The more dramatic in the aspects of science that is represented in the centre, the wider the range of impact on visitors. By using special effects (lighting, audio, video, and darkness) authentic experiences can be enhanced.

The findings from the interview suggests that connection with the subject is important to tap the visitor interest, such as a “wow” effect. Likewise, understanding the social relevance and be able to create an experience that allows the visitor to bring their knowledge, interests and curiosity together is important. Furthermore, topics that justify the expense of erecting new galleries are fundamental in the global community. The integration of all these elements adds to their collective impact. Having exhibition spaces that allow for new stories and regular changes keep the science centre fresh and offer visitors new experiences. To this end, new efforts have been initiated to improve and value-added to visitors’ experiences. Science centre do strive to select representational modes that will be of interest to new people, as well as core returning visitors. There must be a variety on a broad level throughout the museum space, as well as on a personal level, like using big scale and aesthetics that attract special kinds of interest.

ii. Delivering the Message

Designing and developing exhibitions is a complex and organic process with many factors to consider - content, message, exhibits, layout, flow, media, lighting, timeline and many other issues. The theme, delivering the message, explores the pertinence of the interrelationships formed while creating exhibitions. A science centre exhibition can be a difficult format through which to connect with visitors, unless the content is presented in an accessible manner which draws on previous visitor experiences or offers new engaging opportunities.

Science centre provide a point of entry to science and shape visitors' experience and ideas. In preparing to deliver a message, accommodations for diverse visitor values, interests and learning processes is a major consideration. Decision network theory draw on nudging to stimulate visitors’ interest. The exhibitions are a key component in helping visitors make connections with science. Exhibitions layout, visual appeal and feel of an exhibition space set the scene to immerse visitors in a transformative experience. Scenography is expected in today's experience economy, which acts as a flow in the narrative context. The object and information is enhanced in an immersive environment while hands-on exhibits remain as the tool for informal learning. Science discoveries, visual imagery and interactive media can meld together to elicit new personal connections and experiences. A successful experience involved educational, entertaining, aesthetic and escapist experiences as an underline theory by Pine and Gilmore (1999). A designed exhibition experience is shaped by the integration of all the parts. Furthermore, modulating different experiences must be considered in the layout to overcome museum fatigue. The interplay among energized spaces and how the contemplation spaces relate to the information presented are critical in communicating content to visitors.

An exhibition design has to be engaging on so many different levels - visually, sensory, intellectually and emotionally. The finding is consistent with the findings by Serrell (1996) that layering of information as a design technique is to convey message content to a range of visitors. In terms of the subject matter and the layered format of the displays, science centre exhibition’s functionality is designed to be engaging. The findings from the observation is aligned with Keller’s ARCS motivational theory

(Gagne et al., 1992) where an exhibition is intrinsically interesting by addressing the four motivational conditions of: attention, relevance, confidence and satisfaction. Offering a variety of layers for visitors also strengthens an exhibition by providing for different learning styles and multiple intelligences as suggested by Gardner (1983). The exhibition design technique observed correspond with findings in Hood's (1983) study on museum visitor expectations. Hood identified social interaction, active participation and feeling comfortable in one's surroundings as the most valued attributes for occasional museum participants and non-participants. There is a definite overlap between the attributes Hood reported and the techniques identified in this study. In both cases, opportunities for visitors to interact, or connect, with the exhibitions and other people prove to be important.

Exhibitions provide variety on a multiple level - the kind of objects displayed, the sensory experiences provided, the layers of information presented, the learning styles implemented, and the types of media utilized and the levels of interactivity afforded to visitors. The layering of all these individual design components contributes to the strength of the whole. Every detail in an exhibition impacts the message. The case studies offer multiple levels on which visitors can make connections with the varieties of subject range in addition to interdisciplinary approach to exhibition themes. Science centre strives to convey science concepts, issues and its related technology in application to human life and the environment. Careful attention is given on how the exhibition design elements and physical space are combined and presented to create an appealing, inclusive, multi-layered visitor experience.

The findings in this research support the need to identify audiences and utilize formative means to determine how the content should be structured as suggested by Screven (1986). He recommended that exhibition design should involve systematic, goal-referenced evaluation approach. This includes defining the intended audience and educational objectives in measurable terms. Different visitors come to the centre for different reasons, seeking different outcomes, so the same educational objectives may not be relevant for all sets of visitors. Rather than identifying specific learning objectives, the findings from this study suggest focusing on providing a variety of means to impact the visitor's overall exhibition experience. The design of museum exhibitions calls for a more adaptable, audience-focused, constructivist approach in providing learning experiences. The present study provided evidence that designing and developing exhibitions is an involved and ever evolving procedure which goes beyond designing and implementing a task-based plan. The science centres focused heavily on engaging visitor with science and attempting to reach multiple audience segments with these methods.

iii. Connecting Personally

The findings from the interview revealed that the theme connecting personally focuses on the interactions visitors have with exhibition content and the ways science centre can open people's mind to science through experience. The theme delves into the pertinence of the interrelationships formed while experiencing exhibitions as well as collaborations established while creating exhibitions. A science centre interactive exhibition can be a difficult format through which to connect with visitors, unless the content is presented in an accessible and relevant manner which offers new engaging opportunities. Exhibitions are a key component in helping visitors make connections with the information and the science theme presented. Every detail in an exhibition impacts the message, so careful attention must be given on how all the design elements and physical space are combined to create a whole multi-layered visitor experience. The findings indicate that the cases offer multiple levels on which visitors can make connections with the varieties of subject range in addition to interdisciplinary approach to exhibition themes. All the science centres in the study were found to encourage visitors to take science home with them through making science accessible, providing relevance by drawing on personal as well as the social environment and creating new interest by engaging with the aesthetic theme. The reality of museum visit is a challenge when visitors have to balance the precious source of time, value and money. Science centre strives to help people connect with science by drawing them in with a variety of visual elements, presenting objects, providing sensory experiences and sharing a broad range of science concepts visitors may find recognizable or engaging. All the elements must interrelate - the exhibition design must support the theme and connected to the diversity of audiences.

Getting through to visitors is about getting past the surface and striking a chord at a personal level. Achieving this means the layout of the centre, the design of the exhibitions, and the format of the actual content must be presented in a way that is approachable, relevant and easily understood by a range of audiences. The initial impression of the centre must be such that visitors feel comfortable. The overall array of experiences available in the centre is important in making visitors feel they can explore, access and learn from the exhibitions within. Once gaining an initial sense of comfort, visitors must find the contents accessible on multiple levels as they continue to look more closely at the exhibitions. Incorporating exhibits, information and issues within the science centre exhibitions that reflect on visitor's lives or social environment can help cultivate connections. Getting beyond the surface of the exhibition - delving into the context and the concept that the exhibition reflects - is important in making a lasting personal connection with science. Likewise, being able to relate something from one's previous knowledge with something in the exhibition can result in the formation of new knowledge and understanding. By having the opportunity to interact with the exhibitions, visitors are creating foundations for future connections and learning.

The making of museum experience is important in nurturing intellectual and emotional benefits. Learning is not necessarily the targeted goal of an exhibit, but it can be a by-product of the experience. Rather than focusing on learning as an outcome, the research findings suggest that science centre strives to offer visitors stimulating experiences. Unearthing new discovery can pave the way to engaging with science, creating new interest and introducing new ideas. All the science centres in study were found to have the layout of the centre, the design of the exhibitions and the format of the science theme made approachable, relevant and easily understood. The different exhibit styles for the educational/learning experiences such as problem solving exhibit, information communication, exploring physical phenomena, open ended, play form, experimental style as well as quizzes, all have its benefits. The science centres aspire to an environment that combines learning with enjoyment. The findings confirm that all educational endeavours are orchestrated to nurture creativity and there is a clear focus on meaning-making.

iv. Designing Inclusive/Immersive Experience

Designing Inclusive/Immersive Experience focuses on the interactions visitors have with exhibitions and the connections people form with the exhibition content, as well as with one another, as a result of their experiences. This will lead to quality visitor experience. The case studies offer multiple levels on which visitors can make connections with the varieties of subject range in addition to interdisciplinary approach to exhibition themes. The importance and the challenge of designing in anticipation of the visitor's needs are to be able to anticipate the needs of visitor. Science centre recognize that knowing their target audience is critical to effectively conveying information. It is important to accommodate new and different visitors in the exhibition planning process. Science centre aims to attract different audience segments by rotating the exhibitions on display. Developing new exhibitions also allows the opportunity to explore new methods and techniques in exhibition and exhibit design. In developing new exhibitions, there are benefits in promoting new techniques to engage audiences and encourage return visitation. The research findings suggest that sociality and nurturing is deliberately designed in science centre to satisfy the visitor's emotions and pleasure of mind. Design for social situation is a tool to reach a broad range of audiences. Each audience segment has its own set of characteristics and needs. Hence, variety in exhibits can help reach different visitors and attract them to the centre.

Identifying which audiences the centre wants to reach and deciding to broaden the exhibition scope to appeal to those audience segments is the first step in drawing new visitors. Families are one of the primary audience segments most science centres hoped to draw with the exhibitions. Reaching family units was at the heart of the exhibitions. In order to do so, the design team such as in Science Centre Singapore and Questacon conducted research and focus groups to understand ways to weave physical, visual and science connections into a social museum experience for children and family groups. The research findings suggest that many aspects of exhibitions which appeal to children are the components which make science centre experience fun. Adult visitors even those who are not part of a family group, like to be entertained. Visitors should enjoy their time at the science centre. When people are enjoying their visit by interacting with the exhibition and each other, it strengthens all the connections they are making - emotional connections with the scientific content, intellectual connections with their existing knowledge set, and social connections with the others in their group and other visitors. Adding depth and variety to the voice of the exhibitions is a component to establishing an inclusive museum environment.

How science centre addresses its range of visitors can be as important as the information selected to share with them. Minimizing the tone of academic superiority in exhibition content can help visitors be more receptive and feel empowered by the information presented to them. Programs offered can be as important as exhibitions in terms of broadening the target audience and reaching new visitors. As discussed earlier, targeting different audiences and being conscious of how all the elements fit together in an exhibit is critical in designing a successful visiting experience. Finding ways to help a wide range of visitors make connections is often rooted in generating some kind of emotional interest through their museum experience. The entire exhibition design and all the elements used to create the exhibition environment must be considered relative to the target audience in order to maximize the connections a visitor will make. Design for curiosity, virtuosity, sociality and nurturing are the tools. A science centre exhibition can be a difficult format through which to connect with visitors, unless the content is presented in an accessible and fun manner which draws on social situation or offers new engaging opportunities. Interview data analysis revealed that science centre do reach out and foster connections in a diverse subset of audiences by broadening range of audience appeal, providing family friendly experiences and establishing an inclusive museum environment.

v. Balance the Constraints

Interactive exhibits, engaging content and amazing exhibition design plans require adequate resources in order to reach their full potential. The research findings suggest that budget, time and space concerns need to be balanced and waged within the larger science centre context when navigating the exhibition process. Legislation procedures, risk assessment process and changes in government priorities give impacts to the concept, design process, budget and the final exhibit produced. Moreover, exhibition topics will depend on distribution of exhibition resources in terms of time and budget. Reduction in funding increases admission costs and give impact on visitor expectation. This add pressure on balancing limited resources. The image and the opportunities science centre provides, drive the amount and types of funding the centre is able to bring in through grants, donors and government support. The substantial backing is a challenge faced by science centres. In many cases, the government support and private funding does influence the success of the development process. When overall resources are limited - staff, time, and funds are spread thin - there can be strain on the creative aspects of the exhibition process. The pressure to maintain in developing new exhibitions with higher visitor expectations is pertaining to increasing admission costs. Making budget decisions must also take into account the need for the science centre to fund projects which will draw interest and external support. External and internal factors influence the delivery of exhibitions such as the Government, the organization, reducing number of staff expertise and losing corporate knowledge.

The process for deciding an exhibition is varied too. External factors often weigh into the process when it comes to funding. The centre needs to make choices related to the content and type of exhibitions it displays, partially based on acquiring funds and support for the project. The sponsor support and inclination for the project can be a factor that impact the choices related to the content and type of exhibitions it displays. Coordinating the timing for exhibitions can also force decisions and bring about the need for exchange in the exhibition process. When exhibition decisions regarding time are made and passed down from top management, managing an exhibition project requires close attention to the time schedule. This is in addition to careful coordination of all the people and components involved in the process. Staying on schedule is easier to achieve if project considerations - such as timeline, budget, and resources - are clearly identified and communicated to the project team. Well-coordinated project oversight plays a major role in the efficiency with which an exhibition reaches completion. The staff continually balance the time needed upfront to develop ideas against the time required to fabricate those ideas into a tangible exhibition, while taking into account all the steps in between.

Overall project management and long-term exhibition scheduling, as well as the timing and decisions for individual exhibitions, are important. Competition for limited resources can be worsen when the timeframe for completing a project is compressed. Restrictions and limitations in spaces at the centre affect the preparation and display of exhibitions. As such, designing an exhibition requires managing the physical gallery space and balancing the unchangeable, predetermined factors that come with a space. Structural aspects or physical limitations with a gallery space can pose challenges and require aligning or reworking an exhibition design accordingly. Beyond design considerations regarding pre-set, the unchangeable factors of the overall space require the design process to decide and determine exactly how the exhibition space will be configured. Every detail of the space must be considered and factored into the design. Resources are critical to designing and fabricating successful exhibitions so far as exhibitions are critical to the success of the science centre. Besides balancing resources and external factors, the science centre must consider how to balance the impact of the visitor experience through design-related issues such as: the presentation of design elements, access of interactive exhibits, organization and flow of the exhibition and maximizing the value of labels. The research findings from all the cases suggest that science centres struggles with trying to span a continuum of providing visitors with a comfortable and entertaining exhibition experience.

4.6 SUMMARY

The literature and observations in the museum studies suggest that transformational experience evoked most of the pleasant participation and contributed greatly to visitor' positive experiences. As such, atmospherics is the manifestation of a science centre. Details in the physical environment influence visitor perception of the science centre as they take the physical evidence as cues to judge the science centre's offerings. Some seemingly mundane details in the science centre context may evoke visitor participation and make the visitor experience different. The increasing importance of creating transformational experience in science centres through thematization, spatialization, and scenarization of the experience are signs that show the cultural institutional commitment towards experience-based offerings. The findings of this research emphasizes design for curiosity, virtuosity, social interactions and sensorial enhancements. This highlight the importance of experience-oriented approaches in science centre design. The analysis of three dimensional representations, lighting and degree of linearity in science centre on the dimensions of classification, formality and framing revealed the way that visitors are socially constructed as learning subjects. The research findings from the in-depth interview show that invoking interest is a recurring concept in the design development process and implementation of exhibitions at the science centre. The research findings highlight that delivering the message is important in planning and design of science centre exhibitions. Furthermore, the findings emphasize that connecting personally are well thought-out in the design process. The research findings explain the methods used to encourage visitor into having a response. It emphasizes the opportunity of accommodations for diverse visitor values, interests, motivations and learning processes. In terms of design decisions in the exhibition design, this research observe the challenges in maintaining an overall equilibrium in science centre.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter presents conclusions and recommendations from this research. It is divided into four sections. The first section detailed the research conclusions. The second section highlight the research contributions. The third section feature recommendations for future research and the final section conclude the thesis.

5.2 RESEARCH CONCLUSIONS

This research discusses the connection between science centre offerings, exhibition design emphases, and visitor experiences. As set out in Chapter 1 of the thesis, this research was guided by three main aims:

4. To determine the tools for enchantment of message in the science centre experience.
5. To established the interconnection between science centres' representational systems and the tools for enchantment.
6. To explain design opportunities that will improve science centre visitor experience.

To highlight the main results, the following sections present three key findings that emerged from this study:

5.2.1 The Tools for Enchantment of Message in the Science Centre Experience

The objectives of the research are to understand the experiential design strategies that improves science centre intent. This includes understanding the structural dimensions of science centre offer and discuss the characters that structured the experiences offered by these science centres. It looks at how these edutainment offers, which deliberately adopt enchantment experiential strategies, are defined and structured. Enchantment is a feeling of great pleasure, delight or being captivated.

The criterion of enchantment is offered in the scientific content and the mediation tools through the use of thematization, spatialization and scenarization. Science centre offer various techno-scientific themes in delivering the experience. The criterion of thematization is the patterning of space, activity or event to symbolize experiences and/or senses from a specific past, present, or future place, activity or event as currently imagined. Engagement is effected by proposing space to visitors so they can relate in achieving the experience. Besides thematizing the experience, science centre activate spatialization - the physical environment in which the visitor experience occurs, especially through the definition of the architecture, decoration (light, colour, texture) and the general atmosphere of the place. Visitors are to be immersed via work on the physical environment of the exhibition and on the pathways through the exhibition space. Spatialization also involves implementing hyperreal environments. These are reconstructed environments that are more artificial than authentic, combining things real and imaginary. Scenarization of the experience in science centre provide reference points for visitors, to allow them to create meaning and to access the content of experience more easily. The ability of science centre to thematize, spatialize, and scenarize their offers determine the degree of enchantment of the experience.

This study identifies the four experiential dimension in structuring science centre offers in four main symbolic dimensions of spectacularization, immersion, ritualized character and merchandizing the experience. The spectacular character is through the elements of grandiose and ultra-modern architecture. The findings confirmed that science centre offer originality and unique character of the buildings. Immersion through scenography is designed to plunge visitors into simulated reality and to shape their awareness of their immediate immersion. The tools or space offered to visitors is towards achieving the immersive experience. The social dimension of the experience is designed through the common rituals for visitors such as a show that is limited in time and space. This engagement allows visitors to live a form of communion and to share emotions through collective experience. The creation of stores, restaurants, theatres or reception rooms, auditoriums or children's areas do cater for visitors' enthusiasm to multiply the experiences they had at the site.

The research conclude that the relation of exhibition design and learning processes supported in science centre through the idea of enchantment is significant. The tools for enchantment of message in science centre experience is to support forms of thinking. Visitors' motivations and agendas evolved on an ongoing basis as the visitor interacts with the museum environment. In many cases, enchantment has allowed visitors to be drawn into learning experiences, following curiosity and learning for fun. This affective dimension in learning is linked to a motivation of seeking "richness of experience" comprising both entertainment and educational motivations.

5.2.2 The Interconnection between Representational Systems and Enchantment of the Science Centre Experience

This research identifies the sources that generate visitor responses, known as the representational modes in the exhibitions. The logic underlying the structuring of the experience is in its content and the resources employed by the designers. The interconnection between the tools for enchantment and its representational systems are explained from science centre representational expressive modes of three dimensional representations, lighting and degree of linearity. This research identifies the types of epistemological relationship between knowledge categories. Focus is on semiotics semantics theory. This is the study of relationships between signs and symbols and what they represent, especially the relations between written or spoken signs and their referents in the physical world or the world of ideas. Science centre exhibitions offers a common reference to the every-day experiential world of the visitors and this is mainly done by providing examples of the way the specialized scientific knowledge finds applications that change our everyday lives. The degree of abstraction, elaboration and specialization reinforced by the form and function of the three-dimensional representations suggests majority weak classification. The specialized nature of the scientific knowledge does not prevent it from being expressed in codes of low formality. The expressive codes of low formality are very close to the vernacular ways of communicating and to the realistic appearances of things. The attempt is to link the specialized knowledge with the everyday experiential world in terms of its potential to provide explanations about it.

The locus of control over the communication established by the exhibits suggests majority low formality which is reinforced by the colour differentiation, partial or full of the object represented and texture of the three-dimensional representations. As far as the social distribution of the control established in the context of the science centres, visitors are allowed a great deal of autonomy in accessing the exhibits and are also treated as socially equal partners which are highly motivated to get involved together. Lighting has an enormous influence on both the perception of physical space and upon the emotional response of those who enter these environments. These issues are addressed with a strong sense of aesthetics, functionality and quality of light to ensure quality visitor experience. The low levels of formality characterize lighting in its degree of colours realism and degree of directionality. Whereas with respect to their colour differentiation, majority have high formality. The lighting promotes weak levels of framing as majority have uniform of lighting everywhere.

The strength of each exhibit' connections to the other exhibits can be estimated by the existence of signs in morphological features such as common colour, background or lighting, reference to other exhibits, the proximity between the exhibits as well as the presence of connective elements. Degree of linearity with respect to reference to other exhibits, proximity and its connective elements, all suggests weak framing. The design of the exhibitions creates a 'model visitor' who is highly motivated to interact with the exhibits and is also autonomous in deciding his/her own learning experiences (weak framing). The generated sense of self-determination and control over the projected knowledge can reveal the investigative, playful and exploratory nature of science. The increased probability that self-directed learning can occur in a science centre is further reinforced by the fact that such institutions by being multimodal can cater for different learning preferences. Employment of diverse representational modes in science centres is to facilitate visitors' interest in learning. The outcomes of this research also confirm the potential of semiotic semantics in representational modes as a design focus and key direction for future strategic development in informal learning environments.

5.2.3 Design Opportunities in Science Centre Exhibition

Design opportunities to improve visitor experiences is concluded in these issues:

i. Facilitating Visitor Interest and Curiosity

Nurturing visitor interest and curiosity focuses on the interactions visitors have with exhibitions and the connections people form with the identity of the science centre. Through its exhibitions, the science centre seeks to share science by promoting the outward identity and reputation of the centre. Exhibitions at the science centre are inherently tied to the overall mission and identity of the institution. There is a need for the right technique in facilitating an experience to inspire learning in science centre. Processing fluency is a design tool to benefit visitor psychological behaviour in approaching hands-on exhibits. There is also a need to challenge one’s mind as the flow theory recommended. Flow theory is to facilitate curiosity and virtuosity in designing visitor experience. It is important that science centres provide cognitive understanding in delivering the message. Emotional understanding comes from positive evaluation that happened in many stages. These stages of translation in cognitive understanding lead towards the meaning making in exhibition experience.

ii. New Experiences

A successful experience needs to involve all four realms: educational experiences, entertaining experiences, aesthetic experiences and escapist experiences. Findings confirm that some of the concepts practised have design towards escapist experiences with an element of wonder, surprise and dramatic effects. Science centre emphasized these as the core of centre attraction. The more dramatic in the aspects of science that is represented in the centre, the wider the range of impact on visitors. Spectacular design is intended to immerse audiences into a story, give them the opportunity to witness a different world, engage them in hands-on activities and have a lasting impact. The increasing importance of creating memorable experiences in science centres and the rising trend of new exhibition experience, are signs that show the cultural institution's shift towards experience-based offerings. The findings also confirm the literature that science centre design practice emphasizes constructivist learning, social interaction, and sensorial enhancements for experiential impact.

iii. Social Relevance

In order to nurture visitor interest and curiosity, the research participants discuss physical and conceptual ways to establish its identity, share science technology and offer new experiences to it visitors. The connection with the subject is important to tap the visitor interest. Likewise, understanding the social relevance and be able to create an experience in the space that allows the visitor to bring their knowledge, interests and curiosity together is important. Topics that justify the expense of erecting new galleries are fundamental in the global community. The integration of all these elements adds to their collective impact. Having exhibition spaces that allow for new stories and regular changes keep the science centre fresh and offer visitors new experiences.

iv. Opportunities for Active Participation and Visitor Interaction

Opportunities for visitors to interact or connect with the exhibitions and other people prove to be important. Findings conclude that all the science centres in the case studies design for active participation and visitor interaction even though the approached may differ from one another. The science centres which support this approach frequently do so by providing visitors with opportunities to connect with the exhibition environment, to engage with technology and media, and to promote social interaction among visitors. The size and placement of objects invite visitors to become part of the environment - to experience the exhibition on a personal level.

v. Designing a Whole Through the Parts

The combination of actual objects with a wide range of design elements is an important component of the science centre exhibition design approach. Science centres must present a framework for viewing objects which can help a visitor actively explore the science centre environment and make connections to his/her model of the world. Interactive exhibits and immersive exhibitions proved to be a very important aspect of the science centre design. Science centre exhibition themes are presented in a context to provide both a point of entry to understanding science and to help visitors shape their experience and ideas. Display elements, informative text, visuals, audio and multimedia components are utilized to help provide a more concrete experience and contribute to the lens through which visitors interact with the exhibits.

vi. Informal Learning Opportunities

The present study confirms that the focus of exhibitions at the science centre is on providing information and creating an experience - an experience from which informal learning is a possible outcome whereby learning is not a goal, rather a possible incidental outcome. The study adds to the strength of that concept and reinforces the ideathat science centres are places for incidental learning to occur - where visitors can derive their own meaning from the exhibitions they experience. The activities and transaction which takes place between the learner and environment are what constitute a situation with potential for experience based learning. Science centre design its exhibitions that: integrate technology in engaging visitors, offer social opportunities to promote discussion, and utilize interactives to stimulate new ways of thinking.

vii. Visitor Value, Interests and Motivations

The present study substantiates the need to accommodate and design exhibitions with the audience in mind, and sheds light on ways to reach new audience segments, both in theory and in practice. The design process exemplifies how to target a particular visitor group. Identifying and reaching visitors in an effective way is complicated by fact that science centre typically attempt to target multiple audiences with the exhibitions on display. In an attempt to accommodate for a wide range of visitors, science centre integrates variety in format and content presentation - layering of information, visual design styles, layout and interactive components. Diversifying the topics in temporary exhibitions is another way the science centre strives to broaden its range of visitors. Temporary exhibition spaces and the travelling exhibitions provide rotating spaces where the science centre can reflect and cater toward diverse community.

viii. The Challenges of Exhibition Design Development Processes

Available resources often dictate decisions regarding the science centres ability to follow through on design and development. The purpose, format, and expense of proposed exhibition components must be carefully balanced and considered within the larger context of the exhibition plans. The exhibition process is further complicated by a host of challenges posed by decisions related to allocating resources - time, space, and money. These concerns need to be balanced and waged within the larger context when navigating the exhibition process. Legislation procedures, risk assessment process and changes in government priorities give impacts to the concept, design process, budget and the final exhibit produced. Exhibition topics will depend on distribution of exhibition resources in terms of time and budget. Reduction in funding increases admission costs and give impact on visitor expectation. This further add pressure on balancing limited resources. Making budget decisions must also consider the need for the science centre to fund projects which will draw interest and external support. External and internal factors influence the delivery of exhibitions such as the Government, the organization, reducing number of staff expertise and losing corporate knowledge. The centre needs to make choices related to the content and type of exhibitions it displays, partially based on acquiring funds and support for the project.

5.3 RESEARCH CONTRIBUTIONS

Practical insights are among this research contribution. Design opportunities on experiential offerings are suggested to inspire science centre on improvements and possible enchantment for visitor experiences. In terms of design knowledge, this thesis has offered a perspective for considering design in the informal learning setting. It highlights the possibility of exploring the concept of transformational experience in the design of exhibition context. It is a starting point for further research effort in other contexts which will yield more insights on the role of design on visitor participation. This research contributes knowledge by analyzing the representational characteristics in science centres to facilitate understanding the interconnections between types of science centre offerings, design emphases and visitor experiences.

The five themes surfaced in the findings of this study could provide insights to the science centre community in mobilizing exhibition design strategies. For any exhibition, there is a core purpose or objective motivating the design, whether formally defined or informally implied. Conveying an underlying purpose requires presenting information in a way that set visitor on a journey of science discovery. These opportunities can be crafted with different delivery methods, media and formats, but regardless of these specifics, the design must be accomplished in a way with which the visitor can connect. The stronger the engagement and connection, the more the content will resonate with the visitor and the more enduring the impression it will leave.

Regarding research method, this research use photography-based methods in researching about science centre offerings and its design emphases. The photographic medium research method captures the structure of symbolic and experiential offers. This method further explains science centre representational expressive modes. This research has also contributed an analytical template based on the classification, formality and framing theory which is applicable to the data analysis in other semiotic semantics research.

Photographic medium captures detail visually and yields physical evidence of science centre exhibition environments. This finding confirmed that the sites attract and focus attention effectively. Science centre allow visitors to enjoy themselves and create positive attitudes. This research also demonstrated that science centre exhibition environment is designed for cognitive, where visitors absorb and retain information. The site also makes adjustments for differently-abled learners by being compensatory. The compiled results highlighted the case studies science centre’s tools for enchantment, the sources that generate visitor responses, known as the representational modes and the design opportunities in process-related perspectives. It has taken one modest step towards extending the scope of research to accommodating quality visitor experiences. It has also contributed to the multidisciplinary development of design research by synthesizing experience design and exhibition design.

5.4 REFLECTIONS ON RESEARCH FINDINGS

This section examines the outcomes of this research in relation to the current knowledge regarding the interplay between visitors and the exhibition environment in informal learning settings of science centre. It elaborates on the researcher’s reflections towards the relationship between this research and the existing literature.

The findings of the photographic medium study provide keys to understanding the strategies proposed by science centres that may concern curators and science centre managers. Based on a visitor-oriented offer, this type of strategy gives science centre a chance to appeal to a much wider audience than many similar institutions do. This objective is central for science centre managers insofar as they are increasingly required to cater for the broadest audience with educational, leisure, and entertainment functions. At the same time, these offers of experiences have managed to attract more diversified audiences besides schoolchildren and families. These research results confirm four dimensions that structured the experience namely, (1) spectacularization on the architecture forms; (2) the immersive character of the experience by proposing interactive exhibits or space; (3) the ritualized character of the experience through science shows as common rituals for visitors; and (4) the merchandizing of the experience such as gift shops and restaurants. Science centre which have long been thought of as not being subject to market forces, seemed to offer more commercial logic such as extending spaces, developing shops, restaurants and having their own brands for some products as suggested by Werner (2005).

The research findings from the in-depth interview clarify that informal learning environments such as science centre acknowledged the four processes that affect learning: attentional (the sites attract and focus attention effectively); affective (the site allow visitors to enjoy themselves and create positive attitudes); cognitive (visitors absorb and retain information); and compensatory (the site make adjustments for differently-abled learners) as suggested by Prentice et al. (1998). This subsection discusses those confirmatory research outcomes.

i. Attentional

The concepts of exhibition design in science centre inspire interest and curiosity to facilitate visitor attention effectively. For example, processing fluency is the key to attract and fascinate science concepts. Processing fluency is a design tool to benefit visitor psychological behaviour in approaching hands-on exhibits. The processing of any stimulus can be characterized by a variety of parameters that are nonspecific to its content, such as speed and accuracy of stimulus processing. These parameters tend to lead to a common experience of processing ease or "fluency" (Reber, et al. (1998). Science centre also challenge one's mind as suggested by Csikszentmihalyi (1990) in the flow theory.

ii. Affective

Science centre offer visitors stimulating experiences for fun and active exploration that allow visitors to enjoy themselves and create positive attitudes. For example, the different exhibit styles for the educational/learning experiences such as problem solving exhibit, information communication, exploring physical phenomena, open ended, play form, experimental style and quizzes all geared towards creating positive attitudes. Unearthing new discovery can pave the way to engaging with science, creating new interest and introducing new ideas. A successful experience involved educational, entertaining, aesthetic and escapist experiences as an underline theory by Pine and Gilmore (1999).

iii. Cognitive

Science centre exhibition design are engaging on so many levels such as visually, sensory, intellectually and emotionally with the intention of having visitors absorb and retain information. Science centre provides variety on multiple levels - the kind objects displayed, the sensory experiences provided, the layers of information presented, the learning styles implemented, the types of media utilized and the levels of interactivity afforded to visitors. The layering of all these individual design components contributes to the strength of the whole.

iv. Compensatory

Science centres are catering adequately to a wider range of visitors in order to cater for differently-abled learners. For example, the in-depth interview indicated that accommodations for diverse visitor values, interests, motivations and learning process are considered in the design of exhibitions. Science centre do reach out and foster connections in a diverse subset of audiences by broadening the range of audience appeal and providing family-friendly experiences.

5.5 RECOMMENDATIONS FOR FUTURE RESEARCH

After reflecting on the experience of conducting this research as well as insights from exposure to the relevant research fields, four directions are recommended for future research: (1) Audience reactions to the exhibitions/science centre; (2) Media and Technology for Diverse Visitors; (3) Perception and Decoding of Display Elements. These recommendations for future research are explained in detail below.

i. Audience Reactions to the Exhibitions/Science Centre

Reaching and engaging visitors within exhibitions recurred as an area of design concern. Further studies may include visitor tracking, direct observation, surveys and interviews to understand experiential design through factors that had the most impact on their overall visiting experience - taking into account favourite parts of the context, exhibition highlights and effects on different audience segments in these studies.

ii. Media and Technology for Diverse Visitors

Reaching diverse audiences is a goal for many science centres. A comparative study on the utilization of high-tech interactive media components, low-tech interactives, and non-interactive exhibition materials could serve as the structure for the study, with participants representing a wide range of visitor population.

iii. Perception and Decoding of Display Elements

A study on visitor experience relative to display elements in exhibitions is beneficial in determining the expected, perceived, and actual experiences. Objects, visual elements, design components and media devices which attract visitor could be analysed.

5.6 THESIS CONCLUSION

This research discusses the role of the exhibition environment in science centre, towards understanding criteria for the way exhibitions are designed and applying meaningful metrics to the experiences that take place within them. Upon conceptualizing and beginning to formulate this study, a more direct focus was anticipated on the role that enchantment tools play - in science centre exhibitions and the visitor experience. However, in the ever-changing qualitative research path, the researcher came to realize that although the interconnection between science centres' representational systems and the tools for enchantment are regularly implemented in exhibition design (in a wide variety of types and formats), it is impossible to isolate consideration of these components from the entirety and complexity of the exhibition design process. The data collected from participant interviews appeared to focus more on the motivations and intangibles driving the process, rather than the tools and formats in which they manifested. The science being told, the connections being made, and the balancing of a multitude of factors are what really matter in impacting the process and the “whole” exhibition experience which results for visitors.

Achieving this will necessitate both new research and the integration of existing findings from other contexts into the exhibition design process. Design is not clear-cut, it is subjective and dependent upon a whole host of factors which must be considered from the perspective of the managements, designers as well as the targeted audience. The data from the current study indicates that in order to be successful, a balance must be sought and achieved in both the design itself and in the available resources through which it is developed. Science centre make science accessible to a broad range of people in engaging and enjoyable ways. Given the current climate in formal educational institutions, the need to promote and sustain informal learning environments, is even more critical. This is important because informal learning environment offer broad, reflective and immersive learning experiences that cannot be gained from a textbook or a classroom lesson. Acknowledging science centre in terms of people, process, and products could benefit future experience research and informal learning environment practice.

BIBLIOGRAPHY

Abrahams, R.D, (1986). Ordinary and Extraordinary Experience. *Anthropology of Experience*, ed. Victor W. Turner and Edward M. Bruner, Urbana: University of Illinois Press, 45- 72.

Addis, M., Caru`, A. & Rurale, A. (2007). Consumer immersion in aesthetic experiences of arts exhibitions: implications for marketing the arts. 9th International Conference on Arts and Cultural Management, Valencia, Spain, 1-14.

Alessi, S.M. & Trollip, S.R. (2001). *Multimedia for learning: Methods and development.* Boston, MA: Allyn& Bacon.

Alt, M. B. & Shaw, K. M., (1984). Characteristics of ideal museum exhibits. *British Journal of Psychology*, 75, 25-36.

Anderson, G. (2004). *Reinventing the Museum, Historical and Contemporary Perspectives on the Paradigm Shift.* Oxford: Altamira Press.

Anderson, M.L. (1999). Museums of the future: the impact of technology on museum practices. *Daedalus*, 128(3), 129-62.

Anderson, P.& Cook Roe, B. (1993). *The Museum Impact Evaluation Study: Roles of Affect in the Museum Visit and Ways of Assessing Them.* Chicago, IL: Museum of Science and Industry.

Ansbacher, T. (1998). John Dewey’s experience and education: Lessons for museums. *Curator*, 41 (1), 36-49.

Anyfandi, G., Kouladis, V., & Dimopoulos, K. (2010). A social semiotic framework for the analysis of science exhibits. In A. Filippoupoliti (Ed.), Science exhibitions: Communication and evaluation (pp. 102–149). Edinburgh: MuseumsEtc.

Areni, C. & Kim, D. (1994). The influence of in-store lighting on consumers’ examination of merchandise in a wine store. *International Journal of Research in Marketing*, *11*, 117–125.

Aristotle (1996). *Poetics*, M. Heath, trans. London: Penguin Books.

Arnould, E.J. & Price, L.L. (1993). River Magic: Extraordinary Experience and The Extended Service Encounter. *Journal of Consumer Research*, 20 (6), 24-45.

Bærenholdt, J.O., Haldrup, M. & Larsen, J. (2008). Performing Cultural Attractions. *Creating Experiences in the Experience Economy* (Eds.) Jon Sundbo and Per Darmer (176-202).UK: Edward Elgar Publishing, Inc.

Baker, J. (1987). The role of the environment in marketing services: The consumer perspective. In J. Czepiel, C. Congram, & J. Shanahan (Eds.), *The services challenge: Integrating forcompetitive advantage* (79-84). Boston: American Marketing Association.

Baker, J., Levy, M. & Grewal, D. (1992).An Experimental Approach to Making Retail Store Environmental Decisions. *Journal of Retailing*, 68 (4), 445–60.

Barrett, L. F., Mesquita, B., Ochsner, K. N., & Gross, J. J. (2007). The experience of emotion. *Annual Review of Psychology*, *58*, 373–403.

Barriault, C. & Pearson, D. (2010). Assessing exhibits for learning in science centers: A practical tool. *Visitor Studies*, *13*(1), 90–106.

Barthes, R. (1977) *Image, Music, Text*, New York: Hill and Wang.

Beardsworth, A. & Bryman,A. (1999). Late Modernity and the Dynamics of Quasification: The Case of the Themed Restaurants.*The Editorial Board of the Sociological Review*, 228-257.

Becker, H.S. (1979). Do photographs tell the truth? In Cook, T.D. and Reichardt, C.S. (Eds.), *Qualitative and Quantitative Methods in Evaluation Research.* Beverly Hills, CA: Sage.

Beiers, R.J. & McRobbie, C.J., (1992), Learning in interactive science centers, *Research in science education*, 22, 38-44.

Belcher, M. (1991) *Exhibitions in museums*. Washington, DC: Smithsonian Institution Press.

Belk, R.W. & Kozinets, R.V. (2005). Videography in marketing and consumer research. *Qualitative Marketing Research, 8*(2) 128-41.

Bernstein, B. (1996).*Pedagogy, Symbolic Control and Identity: Theory, research, critique*. London: Taylor and Francis.

Bitgood, S. (2002). Environmental psychology in museums, zoos, and other exhibition centers. In R. B. Bechtel & A. Churchman (Eds.), *Handbook of environmental psychology* (461–480). New York: John Wiley & Sons.

Bitgood, S. (2011). Social design in museums: The psychology of visitor studies. Collected Essays (Vol. 1), Edinburgh: Museums Etc.

Bitgood, S. & Patterson, D. D. (1993). The effects of gallery changes on visitor reading and object viewing time. *Environment and Behavior, 25*(6), 761–781.

Bitgood, S., Pierce, M., Nichols, G., & Patterson, D. (1987). Formative evaluation of a cave exhibit. *Curator: The Museum Journal*, *30*(1), 31–39.

Bitner, M. J. (1992). Servicescapes: The impact of physical surroundings on customers and employees. *Journal of Marketing* 5 (2): 57-71.

Bloom, B.S. (Ed.). Engelhart, M.D., Furst, E.J., Hill, W.H., Krathwohl, D.R. (1956). Taxonomy of Educational Objectives, Handbook I*: The Cognitive Domain.* New York: David McKay Co Inc.

Blythe, M. & Hassenzahl, M. (2003). The semantics of fun: Differentiating enjoyable experiences. In M.A. Blythe, K.Overbeeke, A.E. Monk & P.C. Wright (Eds.), *Funology: From usability to enjoyment* (91-100). Boston: Kluwer Academic Publishers.

Bofinger, K. (2010). How to design exhibitions. *Form, 230*(1/2), 32– 45.

Boisvert, D.L. & Slez, B.J. (1995). The relationship between exhibit characteristics and learning associated behaviours in a science museum discovery space, *Science Education*,79, 503-18.

Bonn, M.A., Joseph-Mathews, S. M., Dai, M., Hayes, S., & Cave, J. (2007). Heritage/cultural attraction atmospherics: Creating the right environment for the heritage/cultural visitor. *Journal of Travel Research, 45*(3), 345–354.

Borun, M., Chambers, M., & Cleghorn, A. (1996). Families are learning in science museums. *Curator, 39*(2): 123-138.

Borun, M., Massey, C. & Lutter, T., (1993). Naïve knowledge and the design of science museum exhibits. *Curator*, 36, 201-19.

Boyce, P. (2004). Lighting research for interiors: the beginning of the end or the end of the beginning. *Lighting Research and Technology, 36*(4), 283–294.

Brochu, L. (2003). *Interpretive Planning: The 5-M Model for Successful Planning Projects.* Fort Collins: Interp Press.

Brown, A.L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *Journal of the Learning Sciences, 2*(2) 141-78.

Brown, E. & Cairns, P. (2004). A ground Investigation of Game Immersion. CHI Proceedings, ACM Press, 1297-1300.

Brown, S. & Vaughan, C. (2010). Play: how it shapes the brain, opens the imagination,and invigorates the soul. New York: Penguin Book.

Bruner, E.M. (1986). Experience and Its Expressions. In *Anthropology of Experience*, (Eds.), Victor W. Turner & Edward M. Bruner (3-30).Urbana: University of Illinois Press.

Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, Mass.: Harvard University Press.

Carbonell, B. (2004). Introduction. In Carbonell (Ed.), *Museum studies, an anthology of contexts* (1-14). Maiden, MA: Blackwell Publishing Ltd.

Carù, A. & Cova, B. (2005). The impact of service elements on the artistic experience – the case of classical music concerts. *International Journal of Arts Management*, *7*(2), 39-54.

Carù, A. & Cova, B. (2006). How to facilitate immersion in a consumption experience:appropriation operations and service elements. *Journal of Consumer Behaviour*, *5*(1), 4-14.

Carù, A. & Cova, B. (2007). Consumer Immersion in an Experiential Context in *Consuming Experience* (Ed.), Antonella Carù & Bernard Cova (34-47). New York: Routledge.

Chang, T.Y., & Horng, S.C. (2010). Conceptualizing and measuring experience quality: The customer's perspective. *The Service Industries Journal*, *30*, 2401–2419.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. London: Sage Publications.

Choi, Y. (1999). The morphology of exploration and encounter in museum layouts. *Environment and Planning B: Planning and Design*, *26*, 241–250.

Chui, C. T. B., Rahim, F. A., Hassan, F. H., Musa, R., Yusof, J., & Hashim, R. (2010). Exploring tourist experiencescape and servicescape at Taman Negara National Park. International Journal of Trade, Economics and Fiance, 1(1), 28–31.

Clark, K. A., Smith, R. A., & Yamazaki, K. (2006). Experience design that drives consideration. *Design Management Review, 17* (1), 47-56.

Cobb, P.(1994) Where is the mind? Constructivist and sociocultural perspectives on mathematical development. *Educational Researcher 23*, (7)13-20.

Collier, J. (2003). Photography and visual anthropology. Hockings, P. (Ed.), *Principles of Visual Anthropology* (235-54). New York: Mouton de Guyter.

Corbin, J. & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Thousand Oaks, CA: Sage Publications.

Coulter, P.L. & Lawrence, F.L. (2003). Rethinking the Origins of Involvement and Brand Commitment: Insights from Postsocialist Central Europe. *The Journal of Consumer Research*, *30*, (2) (September), 151-169.

Counts, C.M. (2009). Spectacular Design in Museum Exhibitions. *Curator*, *52*(3) 273-288.

Cova, B. (1997). Community and consumption: towards a definition of the 'linking value' of products and services. *European Journal of Marketing*, 31(3), 297-316.

Cova, B. (2005). Thinking of Marketing in Meridian Terms. *Marketing Theory 5*(2), 205-214.

Crane, V., Nicholson, H., Chen, M. & Bitgood, S. (eds.) (1994). Informal science learning: What research says about television, science museums, and community-based projects. Dedham, Mass: Research Communication.

Crawley, G. (2012). Staging Exhibitions: atmospheres of imagination. In S. MacLeod, L. Hourston Hanks, & J. Hale (Eds.), Museum making: Narratives, architectures, exhibitions (pp. 12–20). Abingdon, Oxon: Routledge.

Cremin, L. (1959). John Dewey and the progressive-education movement, 1915-1952. *The School Review, 67*(2), 160-173.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches*. Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Csikszentmihalyi, M. (1979). The concept of flow. In Sutton-Smith, B. (Ed.), *Play and learning* (257-275). New York: Gardner Press.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* New York: Harper & Row.

Csikszentmihalyi, M. & Halton, E. (1981). *The Meaning of Things: Domestic Symbols and the Self*. Cambridge University Press.

Custers, P., de Kort, Y., IJsselsteijn, W., & de Kruiff, M. (2010). Lighting in retail environments: Atmosphere perception in the real world. *Lighting Research and Technology, 42*(3), 331–343.

Darmer, Per & Jon Sundbo (2008). *Creating Experiences in the Experience Economy*. UK: Edward Elgar Publishing.

David, M., & Sutton, C. D. (2004). *Social research: The basics*. Thousand Oaks, CA: SagePublications.

Davis, J. & Gardner, H. (1999). Open Windows, Open Doors. In Hooper-Greenhill, E. (Ed.), *The educational role of the museum* (2nd ed.) (99-104). London: Routledge.

De Corte, E. (2003).Transfer as the productive use of acquired knowledge, skills, and motivations. *Current Directions in Psychological Science, 12*(4), 142-146.

Demir, E., Desmet, P.M.A., & Hekkert, P. (2009). Appraisal patterns of emotions in human-product interaction. *International Journal of Design, 3*(2), 41-51.

Denzin, N. K. (1998). The art and politics of interpretation. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (313-371). Thousand Oaks, CA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (1994). Entering the field of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2-3). Thousand Oaks, CA: Sage Publications.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds), *Handbook of qualitative research* (1-32). Thousand Oaks, CA: Sage Publications.

Dernie, D. (2006). *Exhibition design*. London: Laurence King Publishing Ltd.

Desmet, P.M.A., Porcelijn, R., & van Dijk, M. (2007). Emotional design; application of a research based design approach. *Journal of Knowledge, Technology & Policy, 20*(3), 141- 155.

Dewey, J. (1933). How we think. A restatement of the relation of reflective thinking to *the educative process* (Revised ed.), Boston: D.C. Heath.

Dewey, J. (1938). *Experience and education*. London: Collier-Macmillan.

Dierking, L.D. & Falk, J.H., (1994). Family behaviour and learning in informal sciencesettings: A review of research. *Science Education*, 78, 57-72.

Diller, S., Shedroff ,N., & Rhea, D. (2006). *Making meaning: How successful businesses deliver meaningful customer experiences*. Berkeley, Calif.: New Riders.

Doering, Z. D. (1999). Strangers, guests, or clients? Visitor experiences in museums. *Curator: The Museum Journal*, *42*(2), 74–87.

Douglas, B. G., & Moustakas, C. (1985). Heuristic inquiry: The internal search to know. Journal of Humanistic Psychology, 25(3), 39-55.

Duffy, T., & Cunningham, D. (1996). Constructivism: Implications for the design and delivery of instruction in *Handbook of research for educational communications and technology* (Ed.), D. H. Jonassen (170-198). New York: Macmillan.

El Guindi, F. (2004). *Visual Anthropology: Essential Method and Theory*. Walnut Creek, CA: AltaMira Press.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing ethnographic field notes.*Chicago: University of Chicago Press.

Ermi, L. & Mäyrä, F. (2005). Fundamental Components of the Gameplay Experience: Analysing Immersion. Changing Views: Worlds in Play. Selected Papers for the *2005 Digital Games Research Association's Second International Conference*, 15-27.

Falk J.H., & Dierking L.D., (1992). *The Museum Experience*. Washington, D.C., USA, Whalesback Books.

Falk, J.H., & Dierking, L.D., (2002). *Lessons without Limit*. Walnut Creek, CA: AltaMira Press.

Falk, J. H., & Dierking, L.D., (2000). *Learning from museums: Visitor experiences and the making of meaning*. Walnut Creek, CA: AltaMira Press.

Falk, J.H., and Dierking, L.D., (2013). *The museum experience revisited.* Left Coast Press, Walnut Creek, California.

Falk, J.H., & Gillespie, K.L. (2009). Investigating the role of emotion in science center visitor learning. *Visitor Studies*, *12*(2), 112–132.

Falk, J.H., Heimlich, J.E., & Bronnenkant, K. (2008). Using identity-related visit motivations as a tool for understanding adult zoo and aquarium visitor's meaning making. *Curator: The Museum Journal, 51*(1), 55-80.

Falk, J. H., Moussouri, T., & Coulson, D. (1998). The effect of visitors' agendas on museum learning. *Curator: The Museum Journal*, *41*(2), 106-120.

Falk, J.H., & Needham, M. (2011). Measuring the impact of a science center on its community. *Journal of Research in Science Teaching*, (48**)**, 1-12

Falk, J.H., Needham, M., Dierking, L.D., & Prendergast, L. (2014). *International science centre impact study. Final report.* John. H. Falk Research, Corvallis, Oregon.

Falk, J. H., & Storksdieck, M. (2005). Using the contextual model of learning to understand visitor learning from a science center exhibition. *Science Education, 89*(5), 744–778.

Featherstone, M. (1991). *Consumer Culture and Postmodernism*, CA: Sage Publications.

Featherstone, M. (1995). *Globalization, Postmodernism and Identity,* London: Sage Publications.

Finkelstein, J. (1989). *Dining out: A sociology of modern manners*. Cambridge, UK: Polity Press.

Finnegan, R. H. (2002). *Communicating: The Multiple Modes of Human Interconnection.* London: Routledge.

Fırat, A. F. & Venkatesh, A. (1995). Liberatory Postmodernism and the Reenchantment of Consumption. *Journal of Consumer Research,* December (22), 239-267.

Fırat, A.F. & Dholakia, N. (1998). *Consuming people. From Political Economy to Theaters of Consumption.* New York: Routledge.

Fırat, A.F. (2001). The Meanings and Messages of Las Vegas: The Present of our Future. *M@nagement*, 4(3), 101-120.

Fırat, A.F.,& Ulusoy, E. (2009). Why Thematization? In Ann L. McGill and Sharon Shavitt (Eds.) *Advances in Consumer Research,36* (777-778).Minnesota: Association for Consumer Research.

Forrest, R. (2013). Museum atmospherics: The role of the exhibition environment in the visitor experience. Visitor Studies, 16(2), 201-211.

Franklin, M. (1994). Art, play, and symbolization in childhood and beyond: reconsidering connections. *Teachers College Record*, *95(4)*, 526-541.

Frey, B. (1998). Superstar museums: an economic analysis. *Journal of Cultural Economics,22* (2/3),113-25.

Fulton Suri, J. (2002) Designing experience: Whether to measure pleasure or just tune in? In W. Green & P. Jordan (Eds.), *Pleasure with products: Beyond usability*, (161- 174). New York: Taylor & Francis.

Fulton Suri, J. (2004). Design expression and human experience: evolving design practice. In D. McDonagh, P. Hekkert, J. van Erp & D. Gyi (Eds.), *Design and emotion: The experience of everyday things*, (13-17). London: Taylor & Francis.

Gagne, R., Briggs, L. & Wager, W. (1992). *Principles of Instructional Design* (4th Ed.). Fort Worth, TX: HBJ College Publishers.

Gardner, H., (1993). *Frames of mind: The theory of multiple intelligences*. New York: Basic Books.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* New York: Aldine Pub. Co.

Gottdiener, M. (1997). *The Theming of America*. Westview: Boulder, Co.

Goulding, C. (2000). The museum environment and the visitor experience. *European Journal of Marketing*, *34*(3), 261–278.

Grabinger, R. S. (1996). Rich environments for active learning in *Handbook of research for educational communications and technology*. (Ed), D. H. Jonassen (665-692). New York: Macmillan.

Gray, C., & Malins, J. (2004). *Visualizing research. A guide to the research process in art and design.* Burlington, VT: Ashgate.

Grbich, C. (2007). *Qualitative data analysis: An introduction.* London: Sage Publications.

Greenhill, E.H. (1999). *The Educational Role of the Museum.* Second edition. London: Routledge.

Griffin, J. (1998). *School-museum integrated learning experiences in science: A learning journey*. Unpublished doctoral dissertation, University of Technology, Sydney.

Gupta, S. & Vajic, M. (2000). The Contextual and Dialectical Nature of Experiences. In James A. Fitzsimmons and Mona J. Fitzsimmons (Eds.), *New Service Development-Creating Memorable Experiences,* (33-51). Thousand Oaks: Sage.

Halliday, M.A.K., (1996). On the Language of Physical Science. In M.A.K. Halliday and J.R.Martin (Eds.), *Writing Science: Literacy and Discursive Power,* (54-68). London: The Falmer Press.

Handley, N. (2014, May). Review of Vikings: Life and legend, British Museum. Museums Journal, 46–49.

Harvey, M. L., Loomis, R. J., Bell, P. A., & Marino, M. (1998). The influence of museum exhibit design on immersion and psychological flow. *Environment and Behavior*, *30*(5), 601–627.

Haywood, N. & Cairns, P. (2005). *Engagement with an interactive museum exhibit.* McEwan, T., Gulliksen, J. and Benyon, D. (Eds), 113-30. Proceedings of HCI 2005, 1. New York : Springer.

Heath, C. & vom Lehn, D. (2008). Configuring 'Interactivity': Enhancing engagement in science centers and museums. *Social Studies of Science, 38*(1), 63-91.

Heimlich, J. E. (2005). Editorial. *Environmental Education Research, 11*(3), 261-263.

Hein, G. (1998). *Learning in the Museum.* London: Routledge.

Hein, G. E. & Alexander, M. (1998). *Museums: Places of learning*. Washington, DC: American Association of Museums.

Hein, G.H. (1999). The Constructivist Museum. In Hooper-Greenhill, E. (Ed.), *The educational role of the museum* (2nd ed.). 73-79. London: Routledge.

Heisley, D. (2001). Visual research: current bias and future directions. *Advances in Consumer Research, 28,*45-6.

Hillier, B., & Tzortzi, K. (2011). Space syntax: the language of museum space. In S. Macdonald (Ed.), *A companion to museum studies* (282–301). Wiley Blackwell.

Holahan, C. J. (1982). *Environmental psychology*. New York: Random House.

Holbrook, M. (2005). Customer value and autoethnography: subjective personal introspection and the meanings of a photograph collection. *Journal of Business Research, 58*(1) 45-61.

Hollenbeck, C.R., Peters, C. & Zinkhan, G.M. (2008). Retail spectacles and brand meaning: insights from a brand museum case study. *Journal of Retailing, 84*(3), 334- 353.

Holloway, I. (1997). *Basic concepts for qualitative research*. Oxford: Blackwell Science.

Hood, M. G. (1983). Staying away: Why people choose not to visit museums. *Museum News, 61*(4), 50-57.

Howard, P. (2010). Foreword. In J. Collins & A. Nisbet (Eds.), *Theatre and performance design: a reader in scenography*. Abingdon, Oxon: Routledge. http:/ files.eric.ed.gov/fulltext/ ED026718.pdf

ASTC. (1973) Association of Science-Technology Centers. Retrieved December 13, 2012. http://www.astc.org/about-astc/about-science-centers/

Hudson, L. & Ozanne, J. (1988). Alternative ways of seeking knowledge in consumer research. *Journal of Consumer Research, 14*(4) 508-21.

ICOM. (2007). International Council of Museums. Retrieved March 20, 2014. http://icom.museum/who we are/the vision/museum-definition.html

Immordino-Yang, M. H., & Damasio, A. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. *Mind, Brain, and Education*, *1*(1), 3–10.

Jackson, P. (1998). *John Dewey and the lessons of art.* New Heaven: Yale University Press.

Jacobson, S. K. (1999). *Communication skills for conservation professionals.* Washington, DC: Island Press.

Joy, A., Sherry, J.F. Jr, Mick, D.G. & Arnould, E.J. (2003). Speaking of art as embodied imagination: a multisensory approach to understanding aesthetic experience. *Journal of Consumer Research*, 30 (2) 259-82.

Keller, J. M. (1983). Motivational design of instruction. In C.M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum, Publisher.

Klein, H.-J. (1993). Tracking visitor circulation in museum settings. *Environment and Behavior*, *25*(6), 782–800.

Klingmann, A. (2007). *Brandscapes: Architecture in the Experience Economy*. MA: MIT Press.

Knudson, D. M., Cable, T., & Beck, L. (1995). Interpretation of cultural and natural resources. State College, PA: Venture.

Kolb, D. A. (1984). *Experiential learning: Experiences as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Koran, J. J., & Koran, M. Lou. (1986). A proposed framework for exploring museum education research. *Journal of Museum Education*, *11*(1), 12–16.

Kotler, N. (1999). Delivering Experience: Marketing the Museum's Full Range of Assets. *Museum News*, 5/6.

Kotler, P. (1974). Atmospherics as a marketing tool. *Journal of Retailing*, *49*(4), 48 - 64.

Kottasz, R. (2006). Understanding the influences of atmospheric cues on the emotional responses and behaviours of museum visitors. *Journal of Nonprofit & Public Sector Marketing*, *16*(1), 95–121.

Koulaidis, V., Dimopoulos, K. & Sklaveniti, S., (2002). The Texts of Science and Technology in the Public Domain: School Science Textbooks and Daily Press Articles. Cope and M.Kalantzis (Eds.), *Learning for the Future: Proceedings of the Learning Conference*. Sydney: Common Ground Publishing.

Koulaidis, V., Dimopoulos, K., & Matiatos, S. (2002). Science and technology centers as 'texts'. *International Journal of Learning, 9*, 717-735.

Kozinets, R. V. (2002). Can Consumers Escape the Market? Emancipatory Illuminations from Burning Man. *Journal of Consumer Research*, 29 (June), 20-38.

Kozinets, R.V., John F. S., Benet D.S., Adam D., Krittinee N., & Diana S. (2002). Themed Flagship Brand Stores in the New Millennium: Theory, Practice, Prospects. *Journal of Retailing*, 78, 17-29.

Kress, G. & van Leeuwen, T., (1996). *Reading images: The Grammar of the Visual Design*. London and New York: Routledge.

Kress, G. & van Leeuwen, T., (2001). *Multimodal discourse: The modes and media of contemporary communication*. London: Arnold.

Kuzel, A. J. (1999). Sampling in qualitative inquiry. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (33-45). Thousand Oaks, CA: Sage Publications.

Landreth, G. L., Ray, D. C, & Bratton, S. C. (2009). Play therapy in elementary schools. *Psychology in the Schools, 46*, 281-289.

Lanier, C.D. & Hampton, R.D. (2009). Experiential Marketing: Understanding the Logic of Memorable Customer Experiences. *Memorable Customer Experiences* (Eds.), Adam Lindgreen, JoëVanhamme, and Michael B. Beverland (1-16). UK: Gower.

Laurel, B. (1991). *Computers as Theatre.* California: Addison-Wesley Publishing Co.

Lave, J., & Wenger, L. (1991). Situated learning: Legitimate peripheral participation. Cambridge, England. Cambridge University Press.

Lawrence-Lightfoot, S. (1997). Illumination: Searching for patterns. In S. Lawrence-Lightfoot & J. H. Davis (Eds.), *The art and science of portraiture* (185-214). San Francisco: Jossey-Bass.

Leard, S.R. (1992). An Examination of the leisure motivations and satisfactions of participants attending the Edmonton Space and Science Centre. (Unpublished master thesis). University of Alberta.

Leinhardt, G., & Knutson, K. (2004). *Listening in on museum conversations*. Walnut Creek, CA:AltaMira Press.

Leinhardt, G., Crowley, K., & Knutson, K. (2002) *Learning conversations in museum.* Mahwah,NJ: Lawrence Erlbaum Associates.

Lin, I. Y. (2004). Evaluating a servicescape: The effect of cognition and emotion. *International Journal of Hospitality Management*, *23*(2), 163-178.

Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry.* Thousand Oaks, CA: Sage.

Lord, G. D. (2007). Museums, lifelong learning and civil society. In B. Lord (Ed.), *The manual of museum learning* (5–12). AltaMira Press.

Lorenc, J., Skolnick, L., & Berger, C. (2010). What is exhibition design?. Mies, Switzerland: Rotovision.

Lukas, Scott A. (2007).Theming as a Sensory Phenomenon: Discovering the Senses on the Las Vegas Strip. In Scott A. Lukas (Ed.), *The Themed Space: Locating Culture, Nation, and Self* (75-95). UK: Lexington Books.

Luria, A.R. (1976). Cognitive development. Cambridge, Mass.: Harvard University Press.

Lytle, & B. Sutton Smith (Eds.), *Play: An Interdisciplinary Synthesis.* Lanham, Maryland: University Press of America.

MacDonald, G.F. and Alsford, S. (1995). Museums and theme parks: worlds in collision? *Museum Management and Curatorship, 14* (2) 129-47.

Macdonald, S. (2007). Interconnecting: museum visiting and exhibition design. *CoDesign*, *3*(1),149–162.

Margolin, V. (1997). Getting to know the user. Design Studies, 18(3), 227-236.

Martin, J.R. and Veel, R., (eds.). (1998).*Reading Science: Critical and Functional Perspectives on Discourses of Science.* London: Routledge.

Maslow, A. H. (1954). *Motivation and personality*. New York: Harper & Row.

McAdam, E. (2011, May). Review of Atmosphere: Exploring climate science exhibition, Science Museum, London. Museums Journal, 42–45.

McAndrew, F. T. (1993). *Environmental psychology*. Belmont, CA: Wadsworth, Inc.

McCarthy, J., & Ciolfi, L. (2008). Place as dialogue: Understanding and supporting the museum experience. International Journal of Heritage Studies, 14(3), 247–267.

McLean, K. (1993). *Planning for people in museum exhibitions.* Washington, DC: Association of Science-Technology Centers.

McLean, K. (2004). Museum exhibitions and the dynamics of dialogue. In G. Anderson (Ed.), *Reinventing the museum: Historical and contemporary perspectives on the paradigm shift*, (193-211). Walnut Creek, CA: AltaMira Press.

McManus, P. M. (1989). Oh, yes they do: How museum visitors read labels and interact with exhibit texts. *Curator, 32*(3), 174-189.

Meerwein, G., Rodeck, B., &Mahnke, F. H. (2007). *Color: Communication in architectural space* (1st English.). Basel: Birkhauser-Verlag AG.

Mencarelli, R. & Pulh, M. (2012). Museoparks and re-enchantment of the museum visits: an approach centred on visual ethnology. *Qualitative Market Research, 15* (2), 148-164.

Meredith, J. E., Fortner, R. W. & Mullins, G. W. (1997). Modes of affective learning for nonformal science education facilities. *Journal of Research in Science Teaching, 34*(8), 805-818.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Merriam, S. B., & Caffarella, R. S. (1999). *Learning in adulthood: A comprehensive guide* (3rd Ed.). San Fransisco: Jossey-Bass.

Meyrowitz, J. (1986). Television and interpersonal behaviour: Codes of perception andresponse. In G.Gumpert and R. Cathcart (Eds.) *Inter/media: Interpersonal communication in a media world* (253-272). New York: Oxford University Press.

Mezirow, J. (1996). Contemporary paradigms of learning. *Adult Education Quarterly, 46*(3), 158-173.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA: Sage Publications.

Miles, M. B., & Huberman, A. M. (2002). Reflections and advice. In A. M. Huberman & M. B. Miles (Eds.)*The qualitative researcher's companion* (393-397). Thousand Oaks, CA: Sage Publications.

Miles, R., Alt, M., Gosling, D., Lewis, B., & Tout, A. (1988). *The design of educational exhibits* (2nd ed.). Allen & Unwin.

Miller, W. L., & Crabtree, B. F. (1999). Depth interviewing. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (89-107). Thousand Oaks, CA: Sage Publications.

Moreno Gil, S., & Ritchie, J. R. B. (2009). Understanding the museum image formation process: A comparison of residents and tourists. *Journal of Travel Research, 47*(4), 480–493.

Morgan, J. M. (2000). Perceptions of a zoological park: A comparative study of educators and visitors. *Journal of Interpretation Research, 5*(1), 19-33.

Morgan, J. M., & Hodgkinson, M. (1999). The motivation and social orientation of visitors attending a contemporary zoological park. *Environment and Behavior, 31*(2), 227-239.

Moscardo, G. (1999). *Making visitors mindful: Principles for creating quality sustainable visitor experiences through effective communication.* Champaign, IL: Sagamore.

Moscardo, G.(1996) Mindful Visitors: Heritage and Tourism. *Annals of Tourism Research*, *23*(2), 376-397.

Moser, S. (2010). The devil is in the detail: Museum displays and the creation of knowledge. Museum Anthropology, 33(1), 22–32.

Muthusamy, S. & White, M. (2005). Learning and knowledge Transfer in strategic alliances: A social exchange view. *Organization Studies, 26*(3), 415-441.

Ng, C. (2003). Satisfying shoppers' psychological needs: From public market to cyber-mall. *Journal of Environmental Psychology*, *23*(4), 439–455.

Norman, D. A. (2004). *Emotional design: Why we love (or hate) everyday things*. New York: Basic Books.

O'Donohoe, S. (1997). Raiding the Postmodern Pantry: Advertising Intertextuality and the Young Adult Audience. *European Journal of Marketing*, *31* (3/4), 234- 253.

Olivera, F. & Straus, S. (2004). Group-to-individual transfer of learning: Cognitive and social factors. *Small Group Research, 35*(4), 440-465.

Oppenheimer, F., (1968). A rationale for a science museum. *Curator*, *11*, 208–211.

Packer, J. (2006). Learning for fun: The unique contribution of educational leisure experiences. *Curator: The Museum Journal*, *49*(3), 329–344.

Packer, J. (2008). Beyond learning: Exploring visitors' perceptions of the value and benefits of museum experiences. *Curator: The Museum Journal*, *51*(1), 33–54.

Packer, J. and Ballantyne, R. (2002) Motivational factors and the visitor experience: a comparison of three sites.*Curator:The Museum Journal, 45*(3), 183-198.

Packer, J., Ballantyne, R., & Bond, N. (2013). Capturing the visitor experience (Unpublished Manuscript, University of Queensland).

Paris, S. & Hapgood, S. (2002). Children learning with objects in informal learning environments. In S. Paris (Ed.), *Perspectives on object-centered learning in museums* (37-54). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage Publications.

Patton, M.Q. (1990). *Qualitative evaluation methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Pekarik, A. J., Doering, Z. D., & Karns, D. A. (1999). Exploring satisfying experiences in museums. *Curator: The Museum Journal, 42*(2), 152-173.

Pekarik, A., Schreiber, J. B., Hanemann, N., Richmond, K., & Mogel, B. (2014). IPOP: A theory of experience preference. *Curator: The Museum Journal, 57*(1), 5–27.

Penaloza, L. (1999). Just doing it: a visual ethnographic study of spectacular consumption behavior at Nike Town. *Consumption, Markets and Culture*, *2*(4) 337-400.

Peponis, J., Dalton, R., Wineman, J., & Dalton, N. (2004). Measuring the effects of layout upon visitors' spatial behaviors in open plan exhibition settings. *Environment and Planning B: Planning and Design*, *31*(3), 453–473.

Perry, D.L. (1992, March/April). Designing exhibits that motivate. *ASTC Newsletter*, *12*, 9-10.

Perry, D.L., (1993). Beyond cognition and affect: The anatomy of a museum visit. *Visitor studies: Theory, Research and Practice*, 6, 43-7.

Philips. (2014). Healthcare business highlights. Philips company website. Retrieved June20,2014. http://www.philips.com/about/company/business/healthcare highlights/

Pine II, B. J. & Gilmore, J.H. (2000). Satisfaction, Sacrifice, Surprise: Three Small Steps Create One Giant Leap into the Experience Economy. *Strategy & Leadership*, 28(1),18-23.

Pine, B. J. I., & Gilmore, J. H. (1999). *The experience economy: Work is theatre & every business a stage*. Boston, MA: Harvard Business School Press.

Poulsson, S.H. & Kale, S.H. (2004). The Experience Economy and Commercial Experiences. *The Marketing Review*, 4, 267-277.

Prentice, R. (1996). Managing implosion: The facilitation of insight through theprovision of context. *Museum Management and Curatorship, 15*(2): 169-185.

Prentice, R., Guerin, S., & McGugan,S. (1998). Visitor learning at a heritage attraction: A case study of discovery as a media product. *Tourism Management, 19*(1), 5-23.

Pullman, M. E. & Gross,M.A. (2004). Ability of Experience Design Elements to Elicit Emotions and Loyalty Behaviors. *Decision Sciences, 35*(3), 551-578.

Rabinowitz, R. (2013). Eavesdropping at the well: Interpretive media in the slavery in New York exhibition. The Public Historian, 35(3), 8–45.

Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science, 9*(1), 45–48.

Rennie, L. J., & Johnston, D. J. (2004). The nature of learning and its implications for research on learning from science museums. *Science Education,* 88, 4-16.

Ritzer, G. (2005). *Enchanting a Disenchanted World: Revolutionizing the Means of Consumption.* CA: Thousand Oaks.

Rojas, M. C., & M. C. Camarrero. (2006). Experience and Satisfaction of Visitors to Museums and Cultural Exhibitions. *International Review on Public and Non Profit Marketing 3*(1): 49-65.

Rojek, C. (1993). After popular culture: hyperreality and leisure. *Leisure Studies*, 12(4), 277-89.

Rook, D.W. (1985). The ritual dimension of consumer behaviour. *Journal of Consumer Research,*12, 251-64.

Roppola, T. (2012). *Designing for the museum visitor experience*. London: Routledge.

Rose, G. (2007). *Visual methodologies: An introduction to the interpretation of visual materials.* London; Thousand Oaks, CA: Sage Publications.

Rosenbaum, M. S., & Massiah, C. (2011). An expanded servicescape perspective. Journal of Service Management, 22(4), 471–490.

Rounds, J. (2004). Strategies for the curiosity-driven museum visitor. *Curator: The Museum Journal*, *47*, 389–412.

Rounds, J. (2006) Doing identity work in museums. *Curator: The Museum Journal, 49*(2), 133-150.

Rui Olds, A. (1994). Sending them home alive. In E. Hooper-Greenhill (Ed.), *The educational role of the museum* (76–80). London: Routledge.

Salmi, H. (2003), Science centres as learning laboratories. *International Journal of Technology Management*, *25(5), 460-475.*

Sawa, A. & Trimis, E. (2005) Responses of young children to contemporary art exhibits: The role of artistic experiences. *International Journal of Education and the Arts,* 6(13), 1-22.

Schauble, L., Leinhardt, G., & Martin, L. (1997). A Framework for Organizing a CumulativeResearch Agenda in Informal Learning Contexts. Journal of Museum Education, 22,(2/3), 3-8.

Schmitt, B. (1999) Experiential Marketing. *Journal of Marketing Management,* 15, 53-67.

Schorch, P. (2013). The experience of a museum space. *Museum Management and Curatorship*, (April), 1–16.

Schwartz, D. (1989). Visual anthropology: using photography in qualitative research. *Qualitative Sociology*, 12 (2), 119-154.

Screven, C.G., (1986). Educational exhibitions: Some areas for controlled research. *Journal of Museum Education*, *11*(1), 7–11.

Screven, C.G., (1990).Uses of evaluation before, during and after exhibit design. International Laboratory of Visitor Studies Review, 1, 36-66.

Seagram, B.C., Patten, L.H. & Lockett, C.W., (1993). Audience research and exhibit development: A framework, *Museum Management and Curatorship*, 12, 29-41.

Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and social sciences* (3rd ed.). New York: Teachers College Press.

Serrell, B. (1996). *Exhibit labels: An interpretive approach.* Walnut Creek, CA: AltaMira Press.

Shedroff, N. (2001). Experience design 1. Indianapolis, Ind.: New Riders.

Shedroff, N. (2006). An evolving glossary of experience design. Nathancom. Retrieved November 7, 2014. http://www.nz\than.com/ed/glossary/

Sherry, J. F., Kozinets,R.V. & Borghini,S. (2007).Agents in Paradise: Experiential Co-creation Through Emplacement, Ritualization, and Community. *Consuming Experience*(Ed.), Antonella Carù and Bernard Cova. (17-33). New York: Routledge.

Sherry, J.F. (1998). The soul of the company store: Nike Town Chicago and the emplaced brandscape. In *Servicescapes*. (Ed.), Sherry, J.F.(109-50). Chicago: AMA.

Shettel, H. (1973). Exhibits: Art form or educational medium? *Museum News, 52*(1) 32-41.

Shettel, H., Butcher, M., Cotton, T., Northrup, J., & Clapp Slough, D. (1968). *Strategies for determining exhibit effectiveness*. Pittsburgh, PA. Retrieved March 23, 2014. http://files.eric.ed.gov/fulltext/ED026718.pdf

Silverman, L. H. (1995). Visitor meaning-making in museums for a new age. *Curator, 38*(3), 161-170.

Singh, S. (2006). Impact of color on marketing. *Management Decision*, *44*(6), 783–789.

Soren, B. J. (2009). Museum experiences that change visitors. *Museum Management and Curatorship*, *24*(3), 233–251.

Spiggle, S. (1994). Analysis and interpretation of qualitative data in consumer research. *Journal of Consumer Research, 21*(12), 491-503.

Spock, D. (2006). The puzzle of museum educational practice: A comment on Rounds and Falk.*Curator: The Museum Journal*, *49*(2), 167–180.

Stenglin, M. K. (2004). Packaging curiosities: Towards a grammar of three dimensional space (Unpublished doctoral thesis). University of Sydney.

Stephens, K. (2009). Imaginative play during early childhood: Required for reaching full potential. *Exchange Magazine. 31*(2), 53-56.

Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Thousand Oaks, CA: Sage Publications.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Thousand Oaks, CA: Sage Publications.

Sundbo, J. & Rasmussen, P.H. (2008). The Backstaging of Experience Production. In *Creating Experiences in the Experience Economy*. (Eds.), Jon Sundbo and Per Darmer (83-111). UK: Edward Elgar Publishing, Inc.

Tannenbaum, P. H. (1971) The indexing process in communication. In W. Schramm, & D. F. Roberts (Eds.), *The process and effects of mass communication* (Rev. ed., pp. 313-325). Urbana: University of Illinois Press.

Tesch, R. (1990). *Qualitative research: Analysis types & software tools.* New York: Falmer Press.

Throop, C.J. (2007). On the Varieties of Experience *The Senses & Society,* 2,(1-March), 109-113.

Tilden, F. (1977) *Interpreting our heritage* (3rd ed.). Chapel Hill: The University of North Carolina Press.

Toon, R. (2005). Black box science in black box science centres. In S. MacLeod (Ed.), *Reshaping museum space: architecture, design, exhibitions* (pp. 26–38). Hoboken, NJ: Routledge.

Trageton, A. (2005). Play in lower primary school in Norway. *In* F.F. McMahon, D.

Turley, L., & Milliman, R. (2000). Atmospheric effects on shopping behavior: A review of the experimental evidence. *Journal of Business Research, 49,* 193–211.

User Experience Network. (2006). User Experience Network. Retrieved November 5, 2014. http://www.umet.org/

Van Boven, L. & Gilovich, T. (2003). To Do or to Have: That is the Question. *Journal of Personality and Social Psychology, 85,* 1193-1202.

Veverka, J. (1994). *Interpretive master planning*. Helena, MT: Falcon Press.

Vygotsky, L.S. (1978). *Mind and society: The development of higher mental processes*. Cambridge, MA: HarvardUniversity Press.

Wagemans, J., Elder, J. H., Kubovy, M., Palmer, S. E., Peterson, M. A, Singh, M., & von der Heydt, R. (2012). A century of gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. Psychological Bulletin, 138(6), 1172–217.

Wagemans, J., Feldman, J., Gepshtein, S., Kimchi, R., Pomerantz, J. R., van der Helm, P. A, & van Leeuwen, C. (2012). A century of gestalt psychology in visual perception: II. Conceptual and theoretical foundations. Psychological Bulletin, 138(6), 1218–52.

Walsh, K. (2003). *Qualitative research: Advancing the science and practice of hospitality.*Thousand Oaks, CA: Sage Publications.

Wasserman, Varda, Rafaeli, A. & Kluger, A.N. (2000). Aesthetic symbols as emotional cues in *Emotion in organizations.*(Ed.), S. Fineman. (140–165). London: Sage.

Weil, S.E. (2002). *Making Museums Matter*. Washington, DC: Smithsonian Press.

Wellington, J., (1989). Attitudes before understanding: The contribution of interactive centers to science education. In M.Quin (ed.), *Sharing science: Issues in the development of interactive science and technology centers,* (30-32). London: Nuffield Foundation on behalf of the Committee on the Public Understanding of Science.

Werner, P. (2005). *Museum, Inc.: Inside the Global Art World.* Chicago:Prickly Paradigm Press.

Wikström, Solveig (2008). A Consumer Perspective on Experience Creation. *Journal of Customer Behavior, 7*(1), 31-50.

Wineman, J., & Peponis, J. (2009). Constructing spatial meaning: Spatial affordances in museum design. *Environment and Behavior*, *42*(1), 86–109.

Wolcott, H. F. (2001). *Writing up qualitative research*. Thousand Oaks, CA: Sage Publications.

Wright, P., McCarthy,J., & Meekison, L. (2003). Making sense of experience. In Blythe, M.A., Overbeeke, K., Monk A.F., & Wright, P.C (Eds.), *Funology: From usability to enjoyment,* (43-53). Boston: Kluwer Academic Publishers.

Xanthoudaki, M., Tickle, L. & Sekules, V. (2003). *Researching visual arts education inmuseums and galleries: An international reader.* London: Springer.

Yellis, K. (2010). Cueing the visitor: The museum theater and the visitor performance. *Curator: The Museum Journal, 53*(1), 87-103.

Yüksel, A. (2009). Exterior color and perceived retail crowding: Effects on tourists' shopping quality inferences and approach behaviors. *Journal of Quality Assurance in Hospitality & Tourism, 10*(4), 233–254.

APPENDIX I

PRELIMINARY ENQUIRIES ON EXPERIENTIAL DESIGN IN SCIENCE CENTRE

1. Why is science centre providing experiences in general?

2. What are the strategies to provide an experience?

3. What is science centre new exhibition experience?

4. How is science centre providing experiential exhibits?

5. Making the scientific issue more "experienceable".

6. Benefits as an informal learning tool.

7. Limitations of science centre experience.

APPENDIX II
SIX-SELECTED SCIENCE CENTRE AS CASE STUDY

1. NATIONAL SCIENCE MUSEUM KOREA

The National Science Museum (NSM) is a representative of national science museum of Korea. The total size is about 165,300 square meters. It was opened in 1990 and consists of many facilities such as permanent exhibition hall, planetarium, movie theatre, special exhibition hall and an outdoor display space (see Figure 1).

Figure 1 : Science Alive Discovery Center at NSM Korea

It is a world class hub for the science center hands-on exhibit and research in Korea. National Science Museum vision is ‘Watch, feel and enjoy science activities centered for general public’. NSM goal is to spread and further the scientific and creative minds. NSM give people a great opportunity to explore and be educated. NSM take pride in servicing people and visitors in exhibitions, science contests and events, education programs and cultural events. There are many exhibition galleries such as the permanent Exhibition Hall; Space Exploratorium, Science Alive Discovery Center, Planetarium and Biosphere. The permanent Exhibition Hall has four main galleries related to: Natural History, History of Science and Technology in Korea, Basic Science and Industrial Technology. Natural History comprises of two main themes; ‘From Space to Humans’ and ‘the Nature of Korea’. History of Science and Technology in Korea displays the ancient history and wisdom of Korean ancestors. The interest varies across astronomy, agriculture and mural paintings. Records of solar eclipses are also in display. Traditional weapons, Korean traditional paper making and construction technology as well as xylography and navigation add to the distinguished collection in NSM. Basic Science exhibition offers an opportunity for visitors to understand logically the scientific phenomena in the everyday life and helps nurture the ability to explore more in depth. Industrial Technology displays humans' constant efforts to enrich their life by utilizing science and technology. The advance of new technologies that enabled faster and more accurate exchange of information triggered a new wave of changes toward the information society.

Campus Map

Figure 2 : National Science Museum Korea Campus Map

The permanent exhibition themes

- Natural History
- History of Science
- Basic Science
- Industrial Technology
- Space Exploratorium
- Science Playground
- Science Alive Center

Exhibition themes highlighted

i. Basic Science

Basic Science exhibition offers an opportunity for visitors to understand logically the scientific phenomena in the everyday life and helps nurture the ability to explore more in depth. (See Figure 3). As described in the preface of the exhibition catalog:

> The Mathematics corner displays hands-on exhibits to help children understand mathematics with ease. Basic Science corner exhibits items on energy preservation, light and sound. It displays hands-on experience installations such as Energy Conservation, Motion Sickness Room and Infrared Light Exploration for visitors' experience.

ii. The Science Playground for Young Children

This fun place for young children is a custom-built environment with many zones to encourage hands-on experiences and exploration through a process of observation, prediction and testing. As a playful space, the exhibition aims for children aged 7 and under to give them an opportunity to promote curiosity and inquiry into our world (See Figure 4).

Figure 3 : Basic Science

Figure 4 : Science Playground

iii. The Science Alive Discovery Center

The Science Alive Discovery Center is a place to experience technology fusion and convergence. Visitors learn scientific principles through direct experiences with the high-tech scientific devices and equipment, and travel into the world of imagination (See Figure 5). Observation can be made to activities at *The Rolling Ball, The Electric Show, Laser Show, Room of Senses, Dark Maze, Media Wall, Motion Capture* and *Virtual Reality Rider* among others.

iv. The Space Exploratorium

The Space Exploratorium draws the public's attention to the new challenge in the 21st century (See Figure 6). In particular, it has been designed to help young people to nurture and present their own ambitions and visions about space development.

Figure 5 : Science Alive Discovery Center

Figure 6 : The Space Exploratorium

2. THE MIND MUSEUM IN MANILA

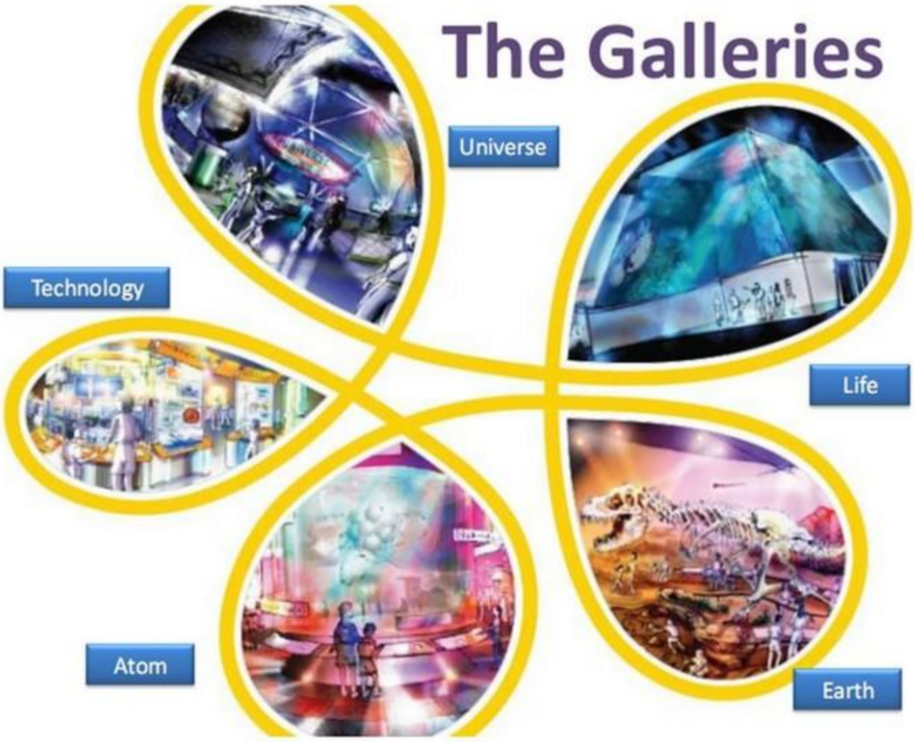
The Mind Museum is the first world-class science museum in the Philippines. The Bonifacio Art Foundation, Inc. started planning for the project in 2007. The Mind Museum opened its doors to the public in March 2012 (See Figure 1).

Figure 1 : The Mind Museum

Figure 2 : Science at the Park

The museum features 4,900 square meters of interactive science and technology exhibitions within five major galleries and outdoor spaces (See Figure 2). With over 250 interactive hands-on exhibits, the museum presents science in a fun, creative and engaging way. The exhibition spans nature in scale, from the smallest thing in nature to the largest and everything in between: Atom, Earth, Life, Universe and Technology.

This museum demonstrates true excellence in design and execution. The exhibits were designed and fabricated mostly by Filipino designers, scientists and fabricators. Each gallery setting is creatively themed and masterfully represented. The thematic thread and artistic treatments throughout the museum is what makes this project extraordinary. In bringing their stories to life, the designers and artists went the extra step in science into a fully experiential world, creating unusual scale, playful details and interactivity throughout. This world-class design combined with sensory-rich experiences make The Mind Museum an achievement in the museum category of

Thea Awards 2014, an internationally recognized award of excellence within the themed entertainment industry. **Diagram Plan Layout**    Figure 3 : The Mind Museum layout
The permanent exhibition themes • Atom Gallery • Earth Gallery • Life Gallery • Universe Gallery • Technology Gallery
Exhibition themes highlighted **i. The Story of the Atom: The Strange World of the Very Small** The Atom Gallery is the gallery with the most number of interactive exhibits. It contains the very elemental forces like gravity and electromagnetism. It also presents

the counterintuitive quantum world that serves as the basis for much of the technology of today.

ii. The Story of the Earth: Nature Across the Breadth of Time

The Earth Gallery features the T-Rex exhibit along with other unique exhibits that focus on forces at work in shaping and reshaping the Earth. Knowing natural history is understanding how long it took the planet to give us what we now inhabit.

iii. The Story of Life: The Exuberance of Life

The Life Gallery features the exuberance of a living planet in all its forms It features the various habitats that nurture an astonishing number and kinds of organisms. The gallery also features the inner spaces that inhabit this life in the form of molecules called DNA.

iv. The Story of the Universe: Its Beginning and Majesty

The Universe Gallery showcases humankind's wondrous fascination with outer space. (See figure 5). It features exhibits that show how all of life, found its atomic beginnings in the stars in space. It enfolds visitors in the fundamental elements and forces at play in the universe. The Universe Gallery includes a mini, teaching planetarium that brings guests closer to the wonders of the universe.

Figure 4 : Life Gallery

Figure 5 : Universe Gallery

vi. The Story of Technology: The Showcase of Human Ingenuity

The Technology Gallery is the largest galleries. The exhibition space is on the second level, overlooking the other four galleries. This gallery presents technology as means to human values. The gallery is divided into five major themes with each theme occupying a Node. The themes of the Nodes are: *How We Live, Who We Are, How We Know, How Things Work, and Here to There*

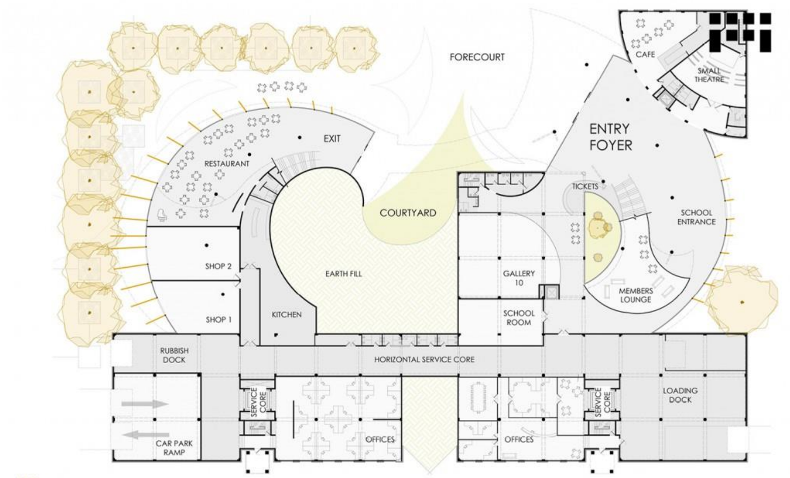
3. QUESTACON IN CANBERRA

Questacon - The National Science and Technology Centre is Australia's largest interactive science centre and an international contributor fostering public engagement with science, technology and innovation. (See Figure 1). In September 1980, Questacon began as a project of the Australian National University (ANU). Staffed by volunteers, Questacon first opened with 15 exhibits. By the mid-1980s Questacon evolved to achieve national recognition. Today Questacon is Australia's largest science centre and is prominent among the world's leading science centres. People have been inspired by engaging with travelling exhibitions, outreach and other national and international programmes. The exhibition themes highlighted here includes Questacon Foyer (See Figure 2), Wonderworks, Q Lab, Awesome Earth, Excite@Q, H_2O Soak Up the Science and Mini Q.

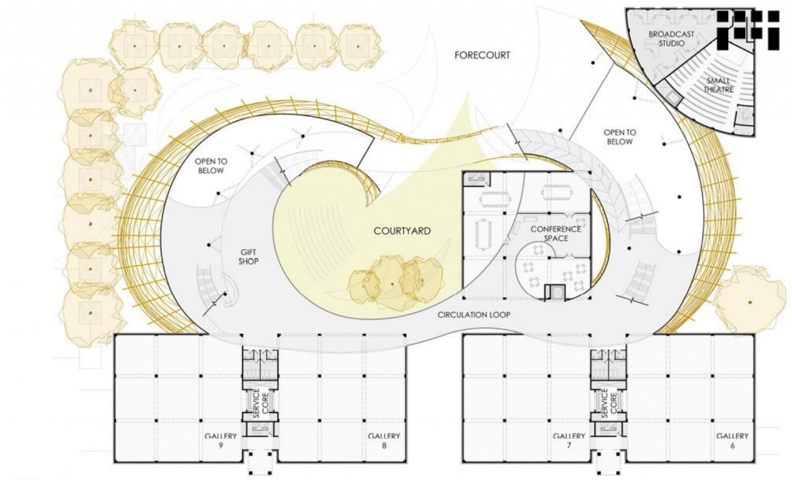
Figure 1: Questacon building

Figure 2: Questacon Foyer

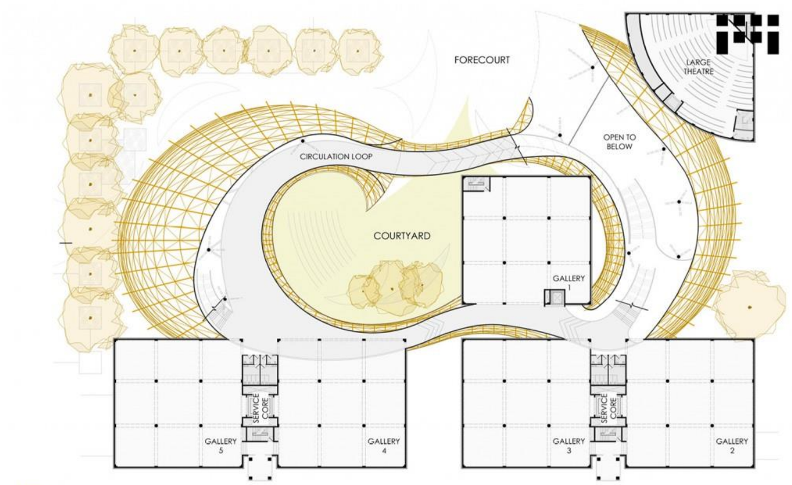
Plan Layout



1:250
GROUND FLOOR PLAN



1:250
FIRST FLOOR PLAN



1:250
SECOND FLOOR PLAN

The permanent exhibition themes

- Questacon Foyer
- Wonderworks
- Awesome Earth
- Excite@Q
- H_2O
- Mini Q
- Q Lab

Exhibition themes highlighted

i. Questacon Foyer

The foyer invites visitors to interact with various exhibits such as the Gravitram, RoboQ, Cam Wave, Clockwork Universe and Eye Spy Pillar. The ramp in its clear pathway is intended to familiarize and enliven the experience of scientific discovery.

ii. Wonderworks

The exhibition explores colour, movement, light and sound (See Figure 3). Visitor can play music using light beams, meditate on the harmonic motion of a pendulum or try to escape the ever-watching gaze of an emu. This gallery's exhibits encourage one to find patterns, beauty and symmetry, which is important in quantifying and predicting phenomena in the world around us (See Figure 4).

Figure 3: Wonderworks entrance

Figure 4: Wonderworks gallery exhibits

iii. Q Lab

This exhibition is a dynamic and experimental environment that encourages enquiry and aims to keep up-to-date with the scientific world (See Figure 5 and Figure 6). Visitors experience a wide range of scientific activities and demonstrations with Questacon's science communicators and visiting scientists.

Figure 5: Q Lab entrance

Figure 6: Q Lab gallery exhibits

iv. Awesome Earth

The exhibition allows visitor to experience lightning and earthquakes from the safety of a Questacon gallery (See Figure 7). The exhibits investigate how natural disasters, weather and geological events are generated by convection currents, wave motion and energy transfer. Exhibits also reveal how scientists predict and measure these events, as well as how humans often respond to natural disasters.

v. Excite@Q

This exhibition is high energy, high impact and highly addictive. It is a complete hands-on, minds-on experience guaranteed to bend both mind and muscle (See Figure 8). The official website highlights:

> Feel the adrenalin pumping as one free fall down a six metre slide or go head over heels on *the 360 Swing!* Battle a robot in a game of air hockey, test your reflexes against your friends or try to keep your balance as you move through the *Rototron.*

Figure 7: Awesome Earth

Figure 8: Excite@Q

vi. H_2O - Soak Up the Science

This is Questacon's permanent exhibition about water and how it shapes human lives and landscapes (See Figure 9 and 10). Visitor can get hands on and boil water, launch a hydrogen rocket, pump water towards the ceiling and reveal how much water is used to manufacture food and clothing. Some exhibits in H_2O explore whether plentiful seawater and waste water can be efficiently converted into freshwater.

Figure 9: Objects on display at H_2O Soak Up the Science

Figure 10: View of H_2O Soak Up the Science main exhibits

vii. Mini Q

Each zone in *Mini Q* encourages carers and their young children to explore their environment through a process of observation, prediction, testing and refining. These processes are used by little (and big) scientists to learn about the world around them, as well as nurturing imagination and growing confidence in the world. Active Play helps children develop physical co-ordination, thinking skills and confidence. Water play - Playing with water improves a child's ability to plan, measure and predict events. (See Figure 11). Role play - Children can observe, imitate and invent make-believe situations (which develop imagination and creativity) (See Figure 12). Set work, toys and props resembling a bakery, Vet or Animal Hospital, Mechanic's Garage and Building Construction Zone. These create an identifiable world for young visitors to pretend they work and live in these worlds.

Figure 11: Mini Q -Water play

Figure 12: Mini Q -Role play

4. MACAO SCIENCE CENTRE

The Macao Science Center (MSC) is a state-of-the-art educational and cultural facility located at the gateway to this special administrative region of China situated along the Pearl River Delta. Opened in January 2010, the 23,000 square meter centre houses interactive exhibition galleries, advanced conference facilities, seminar rooms and a 150-seat planetarium. The focal point of the planetarium is a tilted semi-dome screen nearly 15 metres in diameter and supported by high-definition digital 3D projectors. The building's playful volumes consisting of a rhomboid, a dome and a tilted cone are designed to articulate the functional program, exploit its waterfront setting and to become an instant and enduring landmark of Macao (See Figure 1). Throughout, portals to the sea and sky illuminate the relationship of human achievement and knowledge to the real world. At its summit an observation deck invites visitors to take in a 360-degree view towards the water and the city. The building is clad in shimmering aluminium that responds to and reflects the ever-changing atmosphere of Macao. The plan is organized around clear pathways and choices intended to orient and enliven the experience of scientific discovery and to encourage multiple visits. Modulations of ceiling height, of colour and light levels, and of geometry intensify the anticipation and enjoyment of exhibits. The 5,800 m2 Exhibition Centre, in the shape of an inclined cone, contains fourteen hands-on galleries, arranged inside the building in an upward spiral accommodating a total of 450 interactive exhibits. (See Figure 2).

Figure 1: Macao Science Center

Figure 2: MSC upward spiral pathway

Diagram Plan Layout

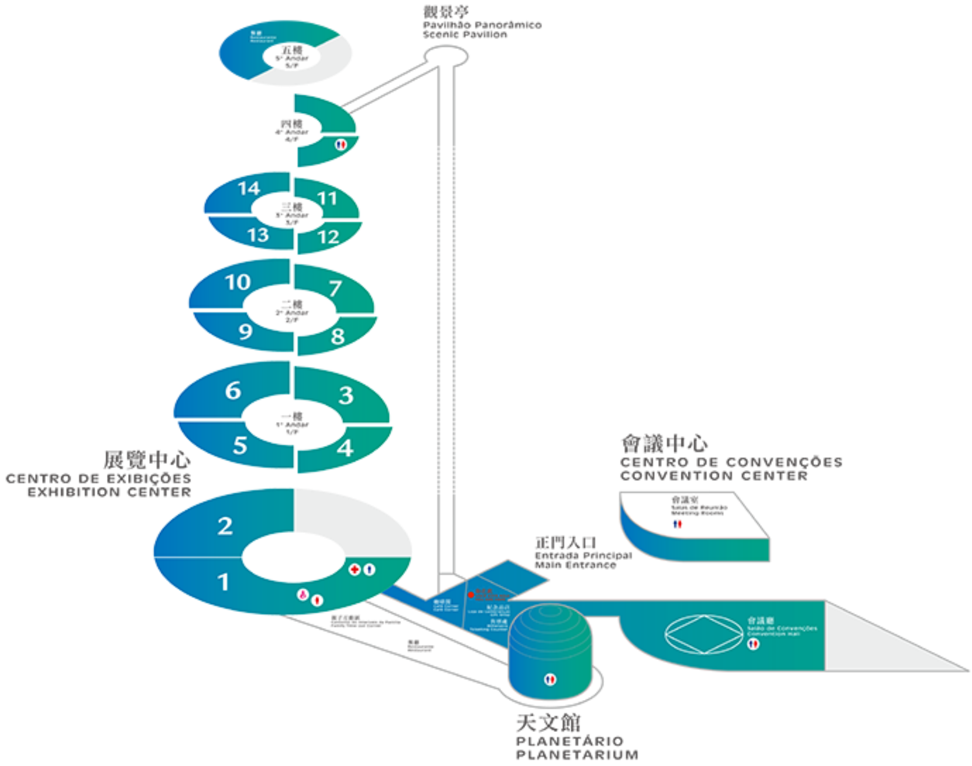


Figure 3: Macao Science Center floor plan

The permanent exhibition themes

- Space Science
- Fun Science
- Science Exploration
- Science Express
- Macao LRT
- Robotic Science
- Sound
- Earth Science
- Eco Conservation
- Sport Health
- Food Science

Exhibition themes highlighted

i. **Space Science Gallery**

Designed in the form of a space science academy, the visitors will learn the basic elements of space exploration and be trained as a future astronaut.

ii. Fun Science Gallery

This gallery introduces science to children who are rich in spontaneous learning, self-discovery and exploration. This area is solely reserved for children not exceeding the appropriate height specified in the gallery, and with their family.

iii. Science Exploration Gallery

This gallery allows visitors to acquire science knowledge through completing and perfecting hands-on tasks. They can either explore individually a group of water-related exhibits, or have fun with 4 themed exhibit tables, or develop social skills through accomplishing tasks with others. Some of the exhibits include:

- Water play area such as Energy store, Slow rising bubbles, Big water vortex and Water wheels (See Figure 4).
- Corpus electricity area such as Generator principle, Series and parallel circuits, Build a battery, Working Models and Artefacts Electricity (See Figure 5).

Figure 4:Water play area

Figure 5: Corpus electricity area

iv. Science Express Gallery

The centre piece of this gallery is the Central Station with the train "Science Express" supported by 4 exhibition zones. The train, through interactive exhibits and a multi-purpose performance stage, will bring children to different areas of science meeting the scientists and their discoveries.

v. Macao Light Rapid Transit

The main intention of this Special Exhibition in Gallery 6 is the presentation of the Macao Light Rapid Transit (MLRT) System as well as the history of the mass transit project and its technologies (See Figure 6). The planned LRT system will be driverless and based on a highly sophisticated signalling system. It will be environmentally compatible and silent owing to the fact that it is rubber-tyres. Its vehicles will run along elevated concrete guideways, ensuring a dedicated right-of-way separated from road traffic.

Some of the exhibits include:

- Interactive map of Macao. (See Figure 7). A huge satellite picture shows not only Macao from a bird's-eye view, but also the new railway network with its stations, emphasized by a bright LED strip light.
- Animation and simulator - Visitors can step into a mock-up of an LRT car and get an impression of the design and comfort of this new means of transport.

Figure 6: Macao Light Rapid Transit (MLRT) gallery

Figure 7: Interactive map

vi. Robotic Gallery

In a deeply buried cave there is a robot factory shop that provides all facilities for understanding and building robots. A number of automatic intelligent robots will be featured. From time to time, state-of-the-art robots will be demonstrated. A workshop will allow participants to create their own robots from parts.

vii. Sound Gallery

There are lots of large musical instruments in the colourful musical world. Visitors can play melodious music with the sound exhibits, and learn the scientific principle behind each one. The contents of the exhibits include sound wave, frequency, sound transfer, and the working principle of each instrument.

viii. Earth Gallery

The Earth Gallery depicts the power of the Earth. It introduces the seemingly peaceful but in fact very dynamic Earth that we are living on top. Exhibits will be themed surrounding the key natural phenomena and their characteristics. The exhibits will provide information on how we can increase our chances of survival when facing them.

ix. Eco Conservation Gallery

This gallery presents a number of ways to protect the environment and how we can minimise the consumption of natural resources in our daily life through 4Rs – reuse, recycle, reduce and replace. Visitors may earn eco-points to become eco-heroes.

x. Sport Health Gallery

Visitor will learn through the exhibits about their personal need in sport activities and physical strength. Gymnastics is the thematic sport selected for detailed introduction. Sport science is helping top athletes to excel through discovering their internal strength in world class competitions. The gallery provides a glimpse of the current researches in sport science with a semi-basketball court showcasing state-of-the-art motion capture system.

xi. Food Science Gallery

This gallery covers topics in food nutrition, food safety, and the science of cooking. The computers will help analysing visitor's choice of food and compare them with the advices from experts.

5. GUANGDONG SCIENCE CENTRE

Located west of Guangzhou University Town in Guangdong Province, Guangdong Science Center (GDSC) is the largest of its kind in China, with a land area of 450,000 square meters and a building floor area of 137,500 square meters. The completion of GDSC in 2008 represents an impressive example of unique architecture, with the applications of various new building technologies, such as the innovative radial-centripetal layout, as well as various energy-efficient and pollutant emission reduction measures including solar energy, energy-efficient air conditioning system and natural ventilation. This building has won many awards as an example of green building in China and has become a landmark of Guangzhou (see Figure 1). GDSC serves as a new educational base for science dissemination, a centre for international academic exchange, and a tourist attraction for leisure. Each exhibition area is more than a compilation of interactive exhibits; they are immersive experiences.

Figure 1: Guangdong Science Center

GDSC contains 8 permanent exhibition halls (Children's Wonderland, Experiments & Discovery, Cyber World, Communications World, Green Homeland, Space Dreams, Human and Health, Perception and Thinking, and Digital Home), with 300 exhibits including 18 theatres (see Figure 2).

Diagram Plan Layout

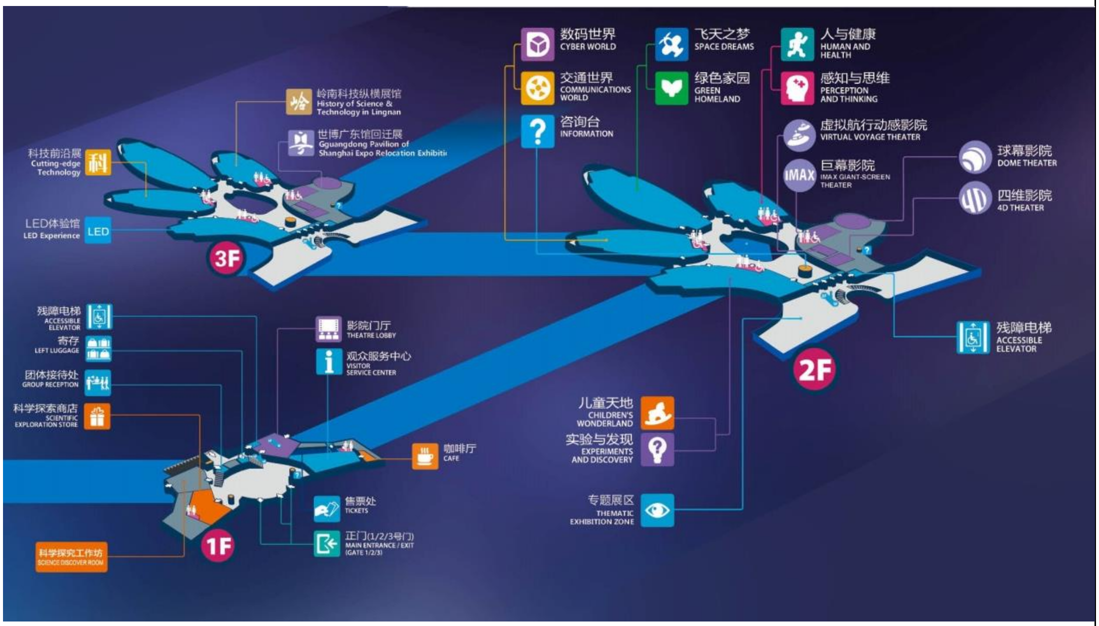


Figure 2 : Guangdong Science Center plan

The permanent exhibition themes

- Children's Wonderland
- Experiment & Discovery
- Cyber World
- Communication World
- Green Homeland
- Space Dreams
- Human and Health
- Perception & Thinking
- Digital Home
- LED Experience Hall
- Development Guangdong

Exhibition themes highlighted

i. Children's Wonderland

It is specially designed for kids aged 12 and below. Through various activities including interactive games, role-playing games and scene experiences, kids can discover the scientific phenomena around them whilst enriching their perception and the experience of childhood and excite their curiosity, imagination and creativity. Some of the sub-areas includes:

- My World features the secrets of nature: displaying the items of agriculture, animals and minerals. It hopes to inspire curiosity and an interest of ecology and teach children to respect nature (See Figure 3).
- My City covers the spectrums of transport, architecture, communication and energy in the city. Little visitors can learn about the theories of science and how to save energy in daily life (See Figure 4).

Figure 3: My World

Figure 4: My City

- Water Playground - Along a meandering river, kids discover villages, dams, rip currents, cities and docks. They build dams for farmland irrigation, operate derrick towers for freight handling, activate hydro powers for urban power supply, and control the ship locks for safe passage of freighters. By all these, kids visually observe the use of water, sinking and floating of objects in water, and the phenomena caused by water pressure and water flow.

ii. Experiment and Discovery

The exhibition area takes one curiosity and imagination on a journey of science discovery. The theme of science discoveries in history is featured through basic sequence of scientific development from classical physics, mathematics and quantum theory. The place has sub-areas named after the world renowned scientists.

- Science Discover Square - Ten classic experiments in the world are shown to outline the chronicle of significant science discoveries (See Figure 5).
- Galileo Laboratory - Clued by the Free Fall theory, the lab introduces his research path on the method of mathematics which initiates the methodology on the base of nature regulation.
- Faraday Laboratory - The lab displays how Faraday explores the regulation of Electromagnetic induction as well as Maxwell's theory of Imagination.
- Newton Laboratory - The lab introduces universal gravitation and the three laws of motion, and displays the principal of how the spheres and earth move and the mechanics system (See Figure 6).

Figure 5 : Science Discover Square

Figure 6 : Newton Laboratory

iii. Communications World

The world focuses on automobile and transport, including the structural principle, manufacturing technology and automobiles culture, as well as application of electronic information, new materials, new energy and new technologies. Visitors can experience the development tendency of rail transit and intelligent transport. The Communications World has four sub-areas:

- Automobile Technology Base introduces the structure, categories, working principle and design process. It offers a real environment of the automobile's interior structure.

- The Latest Automobile Technology showcases the high-technology applied in automobile, including vehicle active safety technology, clean energy, recycling resource. One of exhibits, Simulated Roll-over is an interactive simulation of A 360-degree upturn car design for visitors to experience the overturn danger in vehicles (See Figure 7).
- Future Urban Transport displays the intelligent transport systems in the future cities, such as Bus Rapid Transit (BRT) and Rail Transit (RT) (See Figure 8).
- Vehicle Life and Entertainment introduces the maintenance, repair, energy and culture.

Figure 7 : Simulated roll-over car

Figure: 8 : Future Urban Transport

iv. Green Homeland

Featured Lingnan Ecology, the area displays the panorama of the beautiful nature in a direct and interesting way (See Figure 9). It hopes to advocate green campaign and environment and species protection.

- Green Cradle emphasizes the earth system and structure, balance and recycling of ecology. It displays the four main cycles of the earth microscopically, and the matter recycling and energy flowing inside the earth and its influences on the ecology, as well as the typical ecological systems and resources on the Pearl River Delta region (See Figure 10).
- Green Crisis warns the resource crisis, environment pollution and ecological unbalance and calamity due to the modern industry. An

example of exhibits includes: From Trash to Recycled Materials - Visitors can visually know how much rubbish can be produced by a family in daily life, and accordingly cultivate their consciousness of environment protection, energy saving and emission reduction (See Figure 11).

Figure 9 : Lingnan Ecology pathway

Figure 10 : Ecological systems at Pearl River Delta region

- Green Action shows up the actions of ecology recovery, environment cleaning and new energy development for saving our homeland. An example of exhibits includes: Smart House - Smart House is built on the base of the life in a common family, aiming at establishing the concept that environmental protection is related to our daily life and calls for everyone's effort (See Figure 12). In Smart House, visitors can learn common sense and skills of environmental protection and energy saving in daily life.

Figure 11: From Trash to Recycled

Figure 12: Smart House exhibits

v. Space Dreams

The Space Dreams hall enables visitors to experience the fun of flight and the mystery of the universe, learn aerospace knowledge, and manned space flight program. It aims to encourage the youth to study the cutting-edge technology, keep an eye on the immense universe, and explore the future of human being. The hall has three sub-areas:

- Challenge the Sky - It showcases the aerostatic technology that makes people fly in the sky freely, such as the basic principle of aviation, design and structure of aerostatic engine, aerostatic materials and reliability, control of engine as well as navigation and traffic control on air.
- Fly to the Space - With the background of aviation development of human and China, it introduces the spaceflight knowledge like its principle of launch and flying, and engineering program of manned spaceship (See Figure 13).
- Exploration in the Universe - It displays what human knowledge have comprehended, such as solar system, galaxy and extragalactic system, causing audiences' interest in space mystery and resource exploration (See Figure 14).

Figure 13: Fly to the Space exhibits

Figure 14: Exploration in the Universe

Other exhibits include:

- Electric Swivel Chair - It is a copy of the multifunctional automatic rotary chair for the training for astronauts, but with a smaller rotating speed and swinging scope (See Figure 15). It takes the consideration of ordinary people and decreases the rotating speed and swinging scope.
- Jumping on the Moon - Visitors can slide along the track when lying on a lounge chair and pushing by feet (See Figure 16). The whole process of "jumping" will be recorded and transmitted to the large screen at the front end. Visitors can watch it and see how "high" they jump on the "moon."

Figure 15: Electric Swivel Chair exhibits

Figure 16: Jumping on the Moon exhibits

vi. Perception and thinking

Perception is the foundation of a human's understanding of the world, and thinking is the source of any human's creation of wisdom. This area outlines the perception process, combining knowledge and psychology. Visitors can learn about the mysterious domain of thinking through hands on experiences. The hall has a few sub-areas including:

- Illusion Kingdom - Visitors will experience learning the principles of illusions here (See Figure 17). The phenomenon is immersive in Stealthy Room and Illusion Spinners.
- Thinking Space - One will discover how the brain thinks, learns and remembers things. The use of one's brain is scientifically explained to improve thinking capacity and develop the brain's potential Kingdom - Visitors will experience learning the principles of illusions (Figure 18).

Figure 17 : Illusion Kingdom

Figure 18 : Thinking Space

vii. LED Experience Hall

The LED Experience Hall is functioned with education, display and creation (Figure 19). One can recall the dreamily scene of fireflies in the country, witness how the LED light calculates plants and flowers, view the home illumination at home and experience the tele-communication and network working by LED on air (Figure 20).

Figure 19 : LED home illumination Figure 20 : LED tele-communication

viii. Development in Guangdong -The journey through time

This golden arcade unique style displays Lingnan charm, whimsy back to green living and a way to experience 30 years of development in Guangdong through high-speed speeding ‘intercity train’ (See Figure 21 and Figure 22).

Figure 21: Golden arcade of Lingnan Figure 22: Intercity train journey

6. SCIENCE CENTRE SINGAPORE

Science Centre Singapore (SCS) was opened on 10 December 1977. It was established to promote the dissemination of knowledge in science and technology. SCS showcase exhibits illustrating the physical sciences, life sciences, applied sciences, technology and industry. According to the official website in 1998, the Centre launched a complete refurbishment of its 14 exhibition galleries which was completed in 2003. An expansion in 2000 saw the introduction of an integrated complex consisting of the Annex Building, Kinetic Garden and Snow City (see Figure 1). SCS houses over 1,000 exhibits, including the award-winning Waterworks exhibition, 14 educational laboratories, theatres and a library. While SCS recognised that formal educational institutions will fulfil the primary objective of producing science literate people, there is a need for an environment where the audience can indulge in participatory learning. The institution strives to impact the present and the future population to appreciate aspects of science in a leisurely and entertaining manner. SCS seeks to engage visitors with science through fun and engaging way. The varieties of exhibits spanning various disciplines are basically incubators of scientific knowledge and emphasises hands-on exploratory learning rather than a formal text-based approach. Through innovative science exhibits stressing on aspects of everyday life and other developments relevant to a nation, SCS are ideally poised to play an important role in nation-building efforts.

Plan Layout

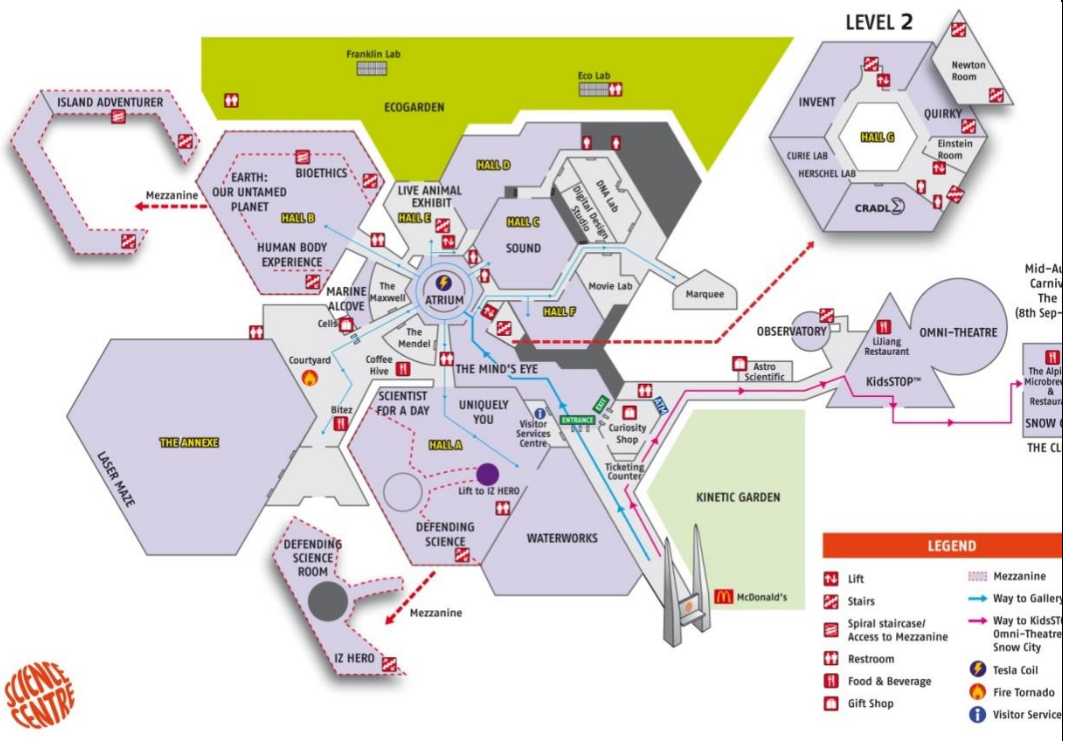


Figure 1 Science Centre Singapore Map

The permanent exhibition themes

- The Mind's Eye
- Uniquely You
- Sound
- Scientist for a Day
- IZ Hero
- Earth Planet
- Marine Alcove
- Invent! It's in you!
- Quirky

Exhibition themes highlighted

i. The 'Mind's Eye'

The 'Mind's Eye' exhibition welcome SCS visitors to have fun experience learning the principles of illusions (see Figure 2). The official website highlights:

> In order to see, your eye must focus light on its retina, convert the light into electrical impulses, and send those impulses to your brain to be interpreted. All this happens almost instantaneously, allowing you to see your surroundings or read a book. However, sometimes this process can play tricks on us. When our brain is tricked into seeing something that is not really there, or it interprets an image wrongly, that's what we call an optical illusion. Illusions can be very deceiving, and magicians use illusions to their advantage to make the audience believe that something happened by magic. The 'Mind's Eye' exhibition reveals some of the secrets behind the illusions. Explore this exhibition to challenge and tease your senses!

Figure 2: The ‘Mind’s Eye’ exhibition Figure 3: Waterworks exhibition

ii. Uniquely You

The Uniquely You exhibition explores the complex combination and interaction of genetic inheritance, environment and lifestyle influences through three sections. This first section of the exhibition 'Balanced You', looks at how the body keeps balance. This balancing act is achieved through a series of feedback mechanisms and is known as homeostasis. The exhibits in this section examine the role of hormones in homeostasis and even the role of your immune system in maintaining balance.

‘Beautiful You’ deals with both attraction and the role of your genes in the early stages of your development. The exhibits featured in this section highlight how our reaction to love is governed by the brain.

'New You' exhibition examines the role of medical science research in aiding our understanding of the human body and our ailments. The exhibits here discuss the ethical implications of our advancing knowledge and challenges visitors to think beyond to a future where humans can transcend biology; to an age where we can change our genes and extend our life.

iii. Sound exhibition

The science of sound is explored by learning about sound waves and how they are transmitted. Visitor can test their hearing range, learn how sound travels through ears and have fun experimenting with the musical exhibits.

iv. Scientist for a Day

Scientist for a Day is a highly interactive, thinking exhibition with a novel, open-to-all Discover-It-Yourself Laboratory or DIY Lab, staffed by SCS resident science educator-facilitator(s) and, when available, guest scientists. The visitor get to learn the scientific method by interacting with the exhibits or observing what happens, then noticing and defining problems based on what has been observed, and raising various explanations or hypotheses. This exhibition offers the opportunity for students and the general public to see how Science works and be that "scientist" for a day.

v. iZ Hero

iZ Hero is a digital exhibition with both panels and games to inform and entertain. Information panels combining hard facts and compelling narrative are mixed with several full body gesture games to appeal to both young and old. iZ Hero is an adventure of how everyone has the seed to be a hero and do the right thing. A semi-linear journey combining storytelling, games and animated characters, iZ Hero externalizes issues such as cyber risks and moral values. In so doing the exhibition not only appeals to children but also provides them with the framework to grasp these issues.

vi. Earth Our Untamed Planet

Created in partnership with Earth Observatory Singapore (EOS), a Research Centre of Excellence at the Nanyang Technological University of Singapore, the Earth Our Untamed Planet exhibition examines the questions of natural disasters phenomena. Visitors can learn scientific principles through current information from scientists and experts, and discover how earthquakes, tsunamis, volcanic eruptions and climate change affect the world. Among the exhibition highlights is *Journey to the Centre of the Earth.* The exhibition starts with a huge quadrant of the globe that looms high overhead. The secrets of the earth begin as one enter through a crack in the surface to begin a journey into the depths of the 'Earth' (see Figure 4). Observation can be made to different layers of the earth. Besides marvel at the movement within the Earth, one can gain a better understanding of how the dynamism within the Earth contribute to our planet.

vii. The Marine Alcove

The Marine Alcove introduces visitors to our ocean, focusing on interesting facts about its physical environment and the creatures living there. You can listen to an underwater symphony of sounds created by the movement of fishes in a tank. You will be able to see close-ups of corals and aquatic creatures and control an underwater camera inside a tank. The Marine Alcove also features some interesting marine life – some very familiar and others rarely seen.

viii. Invent! It's in you!

Invent! It's in you! exhibition is meant to inspire the creative spirit as an inventor in all of us (see Figure 5). The exhibition has four themes: *Inventions Everywhere!, Tinker!, Inventors Spotlight!,* and *Reflect!* This section sets the tone for the whole exhibition, illustrating the universal presence and influence of inventions in our daily lives. The splendour of the invention ideas are celebrated and the push factors that motivate people to invent is highlighted. In *Inventors Spotlight!*, the rich stories and experiences of the selected group of inventors serve as an inspiration.

Figure 4: Quadrant of the globe

Figure 5: Invent! It's in you! exhibition

ix. Quirky

Quirky in SCS is exhibition display of odd things that looks as if it might just come in handy or even solve a problem. The exhibits display strange ideas from one of Leonardo Da Vinci's flying machines to how to hold pages of a book open with one hand. From weird musical instruments to foam lighter than a feather that can carry a brick, these fascinating inventions will make visitor think.

APPENDIX III

Interview questions

5. What design and development processes are used in the design and implementation of exhibitions at the science centre and why are these particular methods used?

6. What does the science centre hope to address and how do they go about addressing it through the planning and design of exhibitions?

7. What educational roles are the exhibitions at the science centre intended to fulfill and how are these roles considered in the design process?

8. What accommodations for diverse visitor values, interests, motivations, and learning processes are considered in the design of exhibitions at the science centre and how are these accommodations addressed in the design process?

Additional framing questions to explore in this research relate to two areas regarding exhibition design decisions and planning in science centre:

(1) Current practices at the science centre

- What concerns were considered in the design of exhibitions?
- What does science centre staff hope/plan to achieve through its exhibitions?
- What issues, realities, and perceptions impact the design of science centre exhibitions?
- What benefits and drawbacks are evident in designing new exhibitions?

(2) Visitor accommodations and experiential value at the science centre

- How important is the need to accommodate new and different visitors in the exhibition planning process? How is this accommodation reflected and addressed?
- How is visitor experience addressed in the exhibition design process?
- What affective learning opportunities do science centre exhibitions intend to provide to their visitors and how are these opportunities supported in the design?
- What other visitor considerations are important to the exhibition design process and how are they negotiated in the final designs?

APPENDIX IV

LIST OF INTERVIEW PARTICIPANTS

	Participants	Designations	Name of centres	Years of experience	Varieties of design involvement
1	John Richardson	Design and Online Services Manager	Questacon, Canberra	6	Responsible for providing graphic design and online services expertise in the development and production of Questacon's exhibition graphic materials, and print based educational, marketing and media products.
2	Daniel Tan	Director Exhibitions Group	Science Centre Singapore	9	Responsible for Project Management, Event Management and Research in the development and production of Science Centre Singapore exhibition management and marketing.
3	Asger Hoeg	Chief Executive Director	Experimentarium, Denmark	23	Asger Høeg is an European Science Centre Association ECSITE Honorary Fellow since 2007, for outstanding merit activity and devotion to the science engagement field. Served as the President of ECSITE from 2004-2007. He also served in the Board of international Association of Science-Technology Centers ASTC and Nordic Science Centre Association. Experienced leader in the Cultural business world including Organizational Development, Strategic Communications and Qualitative Research. He helps conceiving, developing, financing, executing and evaluating communication projects.
4	Maria Isabel Garcia	The Curator	The Mind Museum, Manila	5	Science writer, Curator and Researcher in the development and production of The Mind Museum exhibition management and marketing.

5	Geoff Snowdon	Director Creative Design at Team Aranda Sdn Bhd.	Petrosains, Kuala Lumpur	11	Managed the introduction of Internal Programs for Petrosains including many outreach programs. Experienced in innovative interactive ideas for contemporary museums, science centres, visitor centres and entertainment areas.
6	Fiona Blades	Senior Exhibition Designer	The Powerhouse Museum, Sydney	8	Managed a team of designers with backgrounds in architecture, interiors and graphics, to deliver the exhibition design and other design projects for all sites of the Museum of Applied Arts and Sciences. Supervised the design process from concept to construction.
7	Cindy Chambers	Head of Concepts and Education	Questacon, Canberra	14	Cindy is involved in development of hands-on science, technology and maths exhibits and associated support materials. Her research and interests includes fields of informal learning, science education, science communication, visitor studies and program evaluation.
8	Professor Per-Edvin Persson	Director	Heureka, the Finnish Science Centre	22	Persson has held and holds several positions of trust in science policy in several countries. President of the Nordic Science Centre Association in 1987-1991, of the European Science Centre Association ECSITE in 1997-1998 and of the international Association of Science-Technology Centers ASTC in 2004-2005. He started the tradition of Science Centre World Congresses. In 2007, Persson received the ASTC Fellow Award for Outstanding Contribution. He was elected Ecsite Honorary Member in 2013 and he received the ASPAC President's Award in 2014.

9	Matthew Connell	Principal Curator Physical Sciences and IT	The Powerhouse Museum, Sydney	23	Matthew's research and curatorial interests include computing history, mathematics history, media art and design, interaction design, STEM education and learning, and curatorship. He is currently involved in research projects relating to post-disciplinary curatorship, curating art/science collaborations, audience engagement and learning in maker spaces, and the industrial and cultural implications of digital manufacturing technologies.

APPENDIX V

SAMPLE EMAIL - CONSENT TO CONDUCT AN INTERVIEW

From: Nurhaya Baniyamin <nurhaya2001@yahoo.com> 08/22/13 at 2:44 PM
To: lisa.nicandro@themindmuseum.org

Dear Elisa M. Nicandro
May this mail reach you in the best of health.

The participation from ASPAC 2013 on "Engaging Society with Science" have brought me to write this request. We met earlier during ASPAC meeting with Daniel Loy. My name is Nurhaya Baniyamin from International Islamic Univ. Malaysia.

I plan to visit The Mind Museum between 17th - 19th October 2013 as part of my site visit and data collection for my PhD research. I am conducting a mixed method research on experiential design at Science Centre.

I would like to seek advice and get permission to conduct an interview with the Mind Museum Curator - Madam Maria Isabel Garcia. Given the role at the centre, her ideas and experiences related would be very valuable to my study. I am hoping to get her contact email address to forward this request soon.

I have also attached a copy of my research background and guiding questions for the interview, which will last approximately 40 to 60 minutes.

Do let me know on the process and procedure for this request. I look forward to meet great people at the Mind Museum.

Thank You again.

Nurhaya binti Baniyamin
Kulliyyah of Architecture and Environmental Design
International Islamic Univ. Malaysia

APPENDIX VI

TABLE ANALYSIS RESEARCH OBJECTIVES 1

Science Centre		Tools for Enchantment of Experience			
		Spectacularization	Immersive	Ritualized	Commercialized
1	**Science Centre Singapore**				
	Building Architecture	*			
	The Mind's Eye				
	Uniquely You		*		
	Defending Science				
	Scientist for a Day				
	IZ Hero		*		
	Earth Our Untamed Planet		*		
	Sound				
	Marine Alcove		*		
	Invent				
	Quirky				
	Atrium	*		*	
	Courtyard	*		*	
	Waterworks		*		
	Kinetic Garden		*		
	Omni-Theatre Planetarium	*	*	*	
	Snow City	*	*		
	Curiosity Shop				*
	Cafes & Restaurant				*
		5	**8**	**3**	**2**

Science Centre		Tools for Enchantment of Experience			
		Spectacularization	Immersive	Ritualized	Commercialized
2	**National Science Museum in Daejeon**				
	Building Architecture	*			
	Natural History				
	History of Science and Technology				
	Basic Science				
	Industrial Technology				
	Atrium				
	Space Exploratorium		*		
	Children Science Playground		*		
	Science Alive Discovery Center		*		
	Biosphere	*	*		
	Planetarium	*	*	*	
	Souvenir Shop				*
	Cafe				*
	Science in the Park				
		3	**5**	**1**	**2**

Science Centre		Tools for Enchantment of Experience			
		Spectacularization	Immersive	Ritualized	Commercialized
3	**The Mind Museum in Manila**				
	Building Architecture	*			
	Atom Exhibition Gallery				
	Earth Exhibition Gallery				
	Life Exhibition Gallery		*		
	Universe Exhibition Gallery		*		
	Technology Exhibition Gallery				
	Atrium				
	Souvenir Shop				*
	Café & Restaurant				*
	Science in the Park		*		
		1	**3**		**2**

Science Centre	Tools for Enchantment of Experience			
	Spectacularization	Immersive	Ritualized	Commercialized

4	**Questacon in Canberra**				
	Building Architecture				
	Questacon Foyer		*		
	Wonderworks				
	Q Lab				
	Awesome Earth				
	Excite@Q	*	*		
	H_2O - Soak Up the Science		*		
	Mini Q		*		
	Upward spiral pathway		*		
	Souvenir Shop				*
	Café & Restaurant				*
	Science at the Park				
		1	**6**		**2**

Science Centre		Tools for Enchantment of Experience			
		Spectacularization	Immersive	Ritualized	Commercialized
5	**Macao Science Centre**				

	Building Architecture	*			
	Space Science		*		
	Fun Science		*		
	Children Science		*		
	Science Express				
	Macao LRT				
	Robotic Science		*		
	Science Exploration				
	Earth Science		*		
	Meteorological Science		*		
	Eco Conversation				
	Sports Challenge				
	Food Science				
	Upward spiral pathway	*	*		
	Atrium		*		
	Planetarium	*	*	*	
	Souvenir Shop				*
	Café & Restaurant				*
		3	**8**	**1**	**2**

Science Centre		Tools for Enchantment of Experience			
		Spectacularization	Immersive	Ritualized	Commercialized
6	**Guangdong Science Centre**				
	Building Architecture	*			
	Children's Wonderland		*		
	Experiments & Discovery		*		
	Cyber World				
	Communications World				
	Green Homeland		*		
	Space Dreams		*		
	Human and Health				
	Perception and Thinking		*		
	Digital Home				
	LED Experience Hall		*		
	Development in Guangdong		*		
	Atrium	*	*		
	Planetarium	*	*	*	
	Souvenir Shop				*
	Café & Restaurant				*
	Science at the Park	*			
		4	**9**	**1**	**2**

APPENDIX VII
TABLE ANALYSIS RESEARCH OBJECTIVE 2

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
National Science Museum Korea	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality (high/low)						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differential		Colour modulation		Part of the object represented		Texture		Power relationship		Visitors' involvement		Degree of colours realism		Colour differential		Degree of direction		Intensity of lighting with respect		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Natural History	*	*	*	*		*		*		*		*	*	*	*			*	*			*		*	*		*		*	
History of Science	*	*	*	*		*		*		*		*		*	*			*	*			*		*	*		*		*	
Basic Science		*		*	*		*			*		*	*	*	*	*		*	*			*		*		*		*		*
Industrial Technology	*	*	*	*	*		*			*		*		*		*		*	*			*		*		*	*		*	
Space Exploratorium	*		*			*		*	*		*			*		*		*		*	*			*		*		*		*
Children Playground		*		*		*	*			*		*	*	*		*		*	*			*		*		*		*		*
Science Alive Center		*		*		*	*			*		*	*	*	*	*		*	*		*		*			*		*		*
	4	6	4	6	2	5	4	3	1	6	1	6	4	7	4	5	0	7	6	1	2	5	1	6	2	5	3	4	3	4

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
The Mind Museum in Manila	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Atom Exhibition	*		*			*		*		*		*		*	*			*	*			*		*		*	*			*
Earth Exhibition		*	*			*		*		*		*	*		*			*	*			*		*		*		*		*
Life Exhibition		*	*			*		*	*	*	*	*		*	*			*	*			*		*		*	*		*	
Universe Exhibition		*		*		*		*		*		*	*		*	*	*			*	*		*			*		*		*
Technology Exhibition		*		*	*	*	*	*		*		*		*		*		*	*			*		*	*		*		*	
	1	4	3	1	1	5	1	5	1	5	1	5	2	3	4	2	1	4	4	1	1	4	1	4	1	4	3	2	2	3

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Questacon in Canberra	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Questacon Foyer		*		*		*		*		*		*	*		*			*	*			*		*		*		*		*
Wonderworks		*		*		*		*		*		*		*		*		*	*			*		*		*		*		*
Q Lab		*		*		*		*		*		*		*		*		*	*			*		*		*		*		*
Awesome Earth		*		*		*		*		*		*		*		*		*	*			*		*		*		*		*
Excite@Q		*		*		*		*		*		*	*	*		*	*			*	*		*			*		*		*
H_2O	*	*	*	*	*		*		*	*	*	*	*	*	*	*	*			*		*		*	*		*		*	
Mini Q		*		*		*		*		*		*		*		*		*	*			*		*		*		*		*
	1	7	1	7	1	6	1	6	1	7	1	7	3	6	2	6	2	5	5	2	1	6	1	6	1	6	1	6	1	6

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Macao Science Centre	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Space Science		*		*		*		*		*		*	*		*		*			*	*		*		*		*		*	
Children's Science		*		*		*	*			*		*		*		*		*	*			*		*		*		*		*
Science Express		*		*		*	*			*		*		*		*		*	*			*		*		*		*		*
Macao LRT	*	*	*	*		*		*		*		*		*		*		*	*			*		*	*		*			*
Robotic Science	*	*	*	*	*		*			*		*	*	*	*			*	*		*		*			*		*		*

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Macao Science Centre	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Science Exploration		*		*		*	*			*		*		*		*		*	*			*		*		*		*		*
Earth Science	*		*	*	*			*	*	*	*		*	*	*	*	*			*	*		*		*		*			*
Eco Conversation		*		*	*			*		*		*		*	*			*	*		*		*		*		*		*	
Sport Health Gallery	*		*		*		*		*		*			*		*		*	*			*		*	*		*		*	
Food Science		*		*		*		*		*		*		*	*			*	*			*		*		*		*		*
	4	8	4	9	4	6	5	5	2	9	3	8	3	9	5	6	2	8	8	2	4	6	4	6	5	5	5	5	3	7

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Guangdong Science Centre	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Child Wonderland		*		*		*	*			*		*		*		*		*	*			*		*		*		*		*
Experiment & Discovery		*		*		*		*		*		*	*		*			*	*		*		*			*		*		*
Cyber World	*	*	*	*	*		*			*		*		*		*		*	*			*		*		*		*		*
Communication World		*		*	*		*			*		*	*			*		*	*			*		*	*		*		*	
Green Homeland	*	*	*	*		*		*	*	*		*	*	*	*	*		*	*			*		*		*		*		*
Space Dreams		*		*		*		*		*		*	*	*	*	*		*	*			*		*		*		*		*

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Guangdong Science Centre	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Human and Health	*	*	*	*		*		*	*		*			*		*		*	*			*		*	*		*		*	
Perception & Thinking		*		*		*	*			*	*	*		*		*		*	*			*		*		*		*		*
Digital Home		*		*		*		*		*		*	*	*	*	*	*			*	*		*		*		*		*	
LED Experience Hall		*		*		*		*		*		*		*	*		*			*	*		*		*		*		*	
Dev. Guangdong		*		*		*		*		*		*	*		*		*		*		*		*		*		*		*	
	3	11	3	11	2	9	4	7	2	10	2	10	6	8	6	8	3	8	9	2	4	7	4	7	5	6	5	6	5	6

Science Centre	Three dimensional-representations																Lighting								Degree of Linearity					
Science Centre Singapore	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing (strong/ weak)		Framing (strong/weak)					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
The Mind's Eye	*	*	*	*		*		*	*		*			*		*		*	*			*		*	*		*			*
Uniquely You	*	*	*	*	*		*			*		*	*		*		*		*		*		*			*	*			*
Sound	*	*	*	*		*		*		*		*		*		*		*	*			*		*	*			*		*
Scientist for a Day		*		*		*		*		*		*		*	*	*		*	*			*		*	*		*			*
IZ Hero	*	*	*	*	*		*		*	*	*	*		*	*	*	*			*	*		*		*		*		*	

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
Science Centre Singapore	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing		Framing					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
Earth Planet		*		*		*		*		*		*	*		*			*	*		*		*		*		*		*	
Marine Alcove		*		*	*			*		*		*		*	*		*			*	*		*			*		*		*
Invent	*		*			*		*	*			*		*	*	*		*	*			*		*	*		*		*	
Quirky		*		*		*		*		*		*		*	*	*		*	*			*		*	*		*		*	
	5	8	5	8	3	6	2	7	3	7	2	8	2	7	7	6	3	6	7	2	4	5	4	5	7	2	7	2	4	5

APPENDIX VIII

TABLE ANALYSIS SUMMARY OF REPRESENTATIONAL MODES IN SCIENCE CENTRE

Science Centre	**Three dimensional-representations**																**Lighting**								**Degree of Linearity**					
	Classifications (strong/weak)				Formality (high/low)								Framing (strong/weak)				Formality						Framing		Framing					
	Form		Function		Colour differentiation		Colour modulation		Part of the object represented		Texture		Power relationships		Visitors' involvement		Degree of colours realism		Colour differentiation		Degree of directionality		Intensity of lighting with respect to the surroundings		Reference to other exhibits		Proximity		Connective elements	
	Conventional representation or hybrid	Realistic representation	Classificational, Analytical, Narrative	Metaphorical	One or two colors	Three or more colors	No shades	More than one shades	Partial representation	Full representation	Flat surface	Relief surface	Viewed from below/ large size	Viewed from above/ small size	Visitor can only see the exhibit	Visitor can manipulate the exhibit	Unrealistic colors	Realistic colors	One or two colors	Three or more colors	Focused light beams	Diffuse lighting	Intense lighting	Uniform lighting everywhere	Explicit or implicit reference	No reference	Close or overlapping	Distinct from the other exhibits	Existence	Non-existence
NSM Daejeon	4	6	4	6	2	5	4	3	1	6	1	6	4	7	4	5	0	7	6	1	2	5	1	6	2	5	3	4	3	4
The Mind Museum	1	4	3	1	1	5	1	5	1	5	1	5	2	3	4	2	1	4	4	1	1	4	1	4	1	4	3	2	2	3
Questacon	1	7	1	7	1	6	1	6	1	7	1	7	3	6	2	6	2	5	5	2	1	6	1	6	1	6	1	6	1	6
Macao SC	4	8	4	9	4	6	5	5	2	9	3	8	3	9	5	6	2	8	8	2	4	6	4	6	5	5	5	5	3	7
Guangdong SC	3	11	3	11	2	9	4	7	2	10	2	10	6	8	6	8	3	8	9	2	4	7	4	7	5	6	5	6	5	6
SC Singapore	5	8	5	8	3	6	2	7	3	7	2	8	2	7	7	6	3	6	7	2	4	5	4	5	7	2	7	2	4	5
TOTAL	**18**	**44**	**20**	**42**	**13**	**37**	**17**	**33**	**10**	**44**	**10**	**44**	**20**	**40**	**28**	**33**	**11**	**38**	**39**	**10**	**16**	**33**	**15**	**34**	**21**	**28**	**24**	**25**	**18**	**31**

APPENDIX IX

LIST OF PARTICIPANTS' COMMENTS

Comments	Remark
1	John Richardson, Design and Online Services Manager: *At Questacon the role of the designer is to interpret the brief provided by the Concepts and Education team into physical designs that can be fabricated within time and budget; that comply with various codes and legislation, relevant Australian Standards and comply with requirements under the Work Health Safety Act. With each exhibit the designer considers the intended audience and outcomes of the experience and this provides the framework for their development work.*
2	Maria Isabel Garcia, The curator of The Mind Museum: *Every institution has its own character, and mostly we all value the same things. We share our knowledge and experiences. It's the education, public access and belief in learning through museum experiences. Engaging our audience in aesthetic and interactive experiences is a powerful way to communicate science.*
3	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *The best training for staff will emphasise listening, observing and then leading or facilitating an experience. They should encourage the visitor to learn by leading them with some next questions, or taking them to an exhibit that may help them with understanding. These learning processes in science are about non-closure and an ability to lead with next questions. The SC Exhibits committee need to understand that an exhibit is a prompt for a user. It is a stimulus to inspire learning.*
4	Asger Hoeg, Executive Director of Experimentarium: *The flow theory is very easy to explain because here is a man and he is supposed to make a high jump, if you put it let say 1.2 m and he can jump over, then he's happy and he's in flow. Csikszentmihalyi...said you need to challenge people, but not beyond their ability. So you need to challenge but not too much. You need to arouse curiosity and virtuosity so people feel challenge, but at the end of the day they are doing what they are supposed to do...and they say, yes I understood.*
5	Asger Hoeg, Executive Director of Experimentarium: *The stages of ... [cognitive understanding] ...you had to perceive and then the intrinsic translation of what is happening and then the explicit translation of what is happening and the other evaluation. If you*

	evaluate positive than you actually cognitive...you understand it and also emotionally you understand it.
6	Asger Hoeg, Executive Director of Experimentarium: *So for sure we assure that both entertaining and educational activities are taking place, but aesthetic experience, there are not that many in Experimentarium …therefore we want an aesthetic experience as part of the total experience and also escapist where you really get in flow.*
7	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *The purpose was to understand the theme, to make the exhibition very accessible to people and also to be able to make some changes to it in the future. The previous exhibit such as the Science Time Capsule was the third openings…And, so we tried to find ways that we would be able to change over time… up for the next four or five years.*
8	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *Science Time Capsule indicated the importance of maintaining and displaying niche collections, such as to mark our centre's anniversary theme of 'Celebrating the Past, Shaping the Future'. The exhibition showcased the evolution of Singapore over the past four decades, as well as new items contributed by our industry partners.*
9	Maria Isabel Garcia, The curator of The Mind Museum: *The centre should aim to show the visitor what an amazing story atom is. Showing all the relation and things that make an atom what it is - the substance, relation, composition, from atom to earth, to the universe, etc. - all fuel interest and excitement about the theory for visitors. The more variety in the aspects of connections that are represented, the wider the range of impact on visitors.*
10	Maria Isabel Garcia, The curator of The Mind Museum: *Like reading a novel . . . an exhibition should have highs and lows. I tried to focus on (connections) from the biggest (universe) to the smallest (atom) and on a very basic level about how to connect with the subject, to the material, so visitors feel the story and they want to learn more about it. On an intellectual level visitor might connect in terms of size, volume and forces and what it is about the earth and the solar system right down to the smallest atom...then on a sensory level… the magical night sky and an immersive surrounding that is powerful.*

11	Maria Isabel Garcia, The curator of The Mind Museum: *The museum's main floor has many ideas in life and physical sciences. The second floor is mainly on the theme of technology. The path will lead towards exhibits on 'Who we are', followed by 'How we know', 'Here to there', 'Creative zone', 'How things work' and 'How we live'. We hope the practical of science unfolds naturally this way.*
12	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd : *There are 'beliefs', nominal things that the designers try to take into consideration e.g. ideally each exhibit should occupy around 10 sqm and have 360 degrees access, i.e. people should be able to stand around the exhibit and have good access. This can't always be yet is an ideal. Exhibits should have overhang or design so that a wheelchair can sidle up relatively easily. Accommodation for visually impaired, deaf and others.*
13	Asger Hoeg, Executive Director of Experimentarium: *We are going to make a new exhibition where we should stimulate people interest in exercising, doing fitness, be healthier…the exhibit is actually based on research hypothesis about how you could actually nudge people to exercise more …the exhibition would be a kind of a room for stimulating the interest in your body and that way to be healthier.*
14	Maria Isabel Garcia, The curator of The Mind Museum: *Things that have impact on people are the space they're in. It's like the feeling in a space under the night sky…you walk in there and immediately it's darker. It's more intimate. It focuses you on those views …the planet…you walk into the rotating tunnel and it opens up. I think the experience of three-dimensional space really impact people. I think people respond to great objects, particularly big ones.*
15	John Richardson, Design and Online Services Manager: *If they are not connecting with what they are seeing, then nothing we do that follows up on that visit is going to help very much. If they are disinterested or disoriented or unhappy…that's hard to overcome, and the centre is in one sense it's a physical space with interactives that you want to share with the public.*
16	Asger Hoeg, Executive Director of Experimentarium: *This is five levels. On the 1st floor it will be the light gallery. That is gallery that accept light coming down. The second floor will be the dark gallery. On the third floor we also have the exhibition area where you*

	can come out to exhibition area that is also a dark room and then the 4th floor will be open air. When they change the exterior of the building then it was the chosen project.
17	Asger Hoeg, Executive Director of Experimentarium: *For sure that if you had four kind of the experiences, then you are in the sweet spot. Then you have really the pleasures of the mind then you go out of the Experimentarium willing to come back again. That is why I want to mix art, artifacts and hands-on…I want all kind of experiences design into those experiences.*
18	John Richardson, Design and Online Services Manager: *In terms of working out all of the experiences from design perspectives, I guess we don't really get ask to comment on that. We just get ask to make work what the idea being presented either from exhibition concept perspectives or what the executives want. If it's too much of the same, although we do not decide on the variety of experiences, we throw ideas whether we can do this differently. Make it a 'different' feel so you can be having a different experience than the previous gallery that you visit to.*
19	Asger Hoeg, Executive Director of Experimentarium: *Scenography is only the tool to make people work with the hands-on exhibits. So you need scenography but not too much and don't believe that scenography can do the work. It is the hands-on exhibits that do the work but scenography can nudge the visitors to do and work with the hands-on exhibits.*
20	Asger Hoeg, Executive Director of Experimentarium: *The theme in a science centre is a challenge. What can the visitor find out? What is now happening…and what is now happening? There was a submarine conquered 1944 in World War II that go to Chicago and it was then displayed in the Museum of Science and Industry in Chicago. I visited this submarine 20 years ago and OK there was a submarine, but then they built a building around the submarine and then they used the submarine via scenography…and then after 20 minutes of introduction, you came to the submarine and I got tears in my eyes…I was much more interested in the topic. So the scenography is to make people be ready to work with what you're supposed to do, to be interested in the story. Scenography should bring visitor to a flow…with the help of the surrounding.*
21	Cindy Chambers, Head of Concepts and Education at Questacon:

	The Gardner theory of learning styles isn't just for children. It's for adults so the layering of information…children need little invitation to become involved. So the experience has to be the first thing they do. The riding on the wheels, the climbing on the construction site, the leaning over.
22	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *I think that [variety is] one of the things that, SCS does it pretty well. There are things for children…having the activity buttons helps…And the thing is there's an adult layering, too…so we can appeal to both sides. Children are excited about the 'centre of the earth' and the journey section, and things like that…that they can relate to or things that are presented in a way that they can actually connect with.*
23	John Richardson, Design and Online Services Manager: *Questacon produces exhibitions with a preference for open-ended exploration and interactivity over didactic display methods. Whilst there will be common elements, each project is unique in some way and the teams are continually faced with new challenges. The designers are not responsible for developing content and are briefed by Concepts and Education staff as to the required key communication aims and the scientific and educational outcomes. The designers use their specific skills and experience to interpret each brief into a design that delivers the intended outcomes. Testing designs with visitors is important and provides valuable insights.*
24	John Richardson, Design and Online Services Manager: *Questacon as a building can also limit us physically on what we want to do, so we do try to modulate different experiences. You might find Q Lab in gallery 4, a place for interchange among the staff and the public. It's a very different kind of approach. Say, Wonderworks where you wonder around and play with the exhibits. It is an interaction within that space but in a smaller scale.*
25	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *SC's have an altruistic dream – they would love for people to come along, have a positive experience and go back with an increased positive view of science and how science contributes to their lifestyle. SC's do seek to address popularity of science. They seek to have visitors receive a positive visit and go back thinking some more about science. Yet to believe a less than 2 hr visit once in a year and often once in a lifetime can achieve that end certainly is fodder for a skeptic!! The majority of parents have bad memories of science at school…they got 'low marks' or were not even allowed to do 'science stream'.*

26	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *The majority of parents have very little time to decide how they will use precious non-school time with their children. This is quite often the task of mothers – what to do, where to take children this weekend for the money we can afford, the time we can afford. Why will mum choose a SC?...after all what is a SC to mum? Families do visit often because someone said this is a worthwhile visit. They arrive not sure of what the SC actually is and how to best make use of the visit.*
27	Cindy Chambers, Head of Concepts and Education at Questacon: *Museums are very important for social recreation education. As the boss often said ' I don't wake up in the morning and think I am going to the science centre to learn about science, they wake up and say I am going to the science centre because I want to share learning for fun, with my children or my guests in town'. So it creates an opportunities for visitors to have a social experience that is based on science. The way another saying is how you feel when you learn something is really important, so try to make it a little bit more accessible. I am doing science because it's really intriguing, makes me curious, I can laugh at you because you look silly in this exhibit, that's the perception going on behind it.*
28	John Richardson, Design and Online Services Manager: *Why Questacon is doing what it's doing – we want our visitors to pick up some inspirations so they become interested in science. Perhaps it's about translating a child who have no idea about science and get them into starting to think about science. It might be little steps at a time. So we start at a very early age, we look at adult also these days but traditionally its 8 to 14 years of age, the idea is like as they leave the building, if they're impressed in some way, they responded in appropriately and its quite an experience, that's a good outcome for us and that's the whole visitor experience that we want to happen, we hope they go through science as a career. That's the payoff. That's what we're trying to encourage. It's like to break down the barrier, because science – it can be terrified, it's too complicated, so we want to encourage to break down the barrier or the boundaries.*
29	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *I think it's to be more accessible to all audiences. ...What's nice about the size of this centre and the types of exhibitions, there seems to be something for everyone....through the lobby, the water park, planetarium ...and the galleries, the central node is setting a theme for*

	the centre in terms of welcoming and offering visitors many path and options of experiences.
30	John Richardson, Design and Online Services Manager: *In navigation, it's like the Guggenheim style museum, as one move from up along the ramp, and move down one gallery after another, along the drum. A number of years later, they change it, in reverse where we have to go up. Then about two years ago, they change it back to the original design to accommodate the public coming from the parking. The foyer ceremonial entrance is for the official and school trip. They turn the rear entry to a more accessible entry via open podium and café. It seemed to be working. The foyer level has been used in many ways.*
31	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *The SC more often than not in its altruism provides for a multi audience yet when pushed will admit that the texts and graphics and educational approaches targets families with young children (primary age). There is a very real 'science' in how to produce text for exhibits; just how authoritative should the text be?; Should text be largely questions that lead and assist discovery? In the preciously short time in their visit to the science centre, can exhibit designers get people to be more inquisitive? Can they increase the sense of wonder?*
32	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *I think that people have been very interested in The Mind's Eye area near the lobby. They remember the interaction and things like that or…certainly, in the Tesla Coil demonstration, a highly dramatic live demonstration of high voltage electricity; they see action…They do feel the intense…The Fire Tornado Demonstration…even if it's something that has been there before, repeat visitors are still able to find something that they can relate to.*
33	Matthew Connell, the Principal Curator of Physical Sciences and IT at the Powerhouse Museum: *People really seem to connect to (Outerspace) on this personal level… to be walking through the gallery and have a visitor stop you and say, "Do you have anything on the space shuttle? …I think it's most effective and may not be apparent with how long they play with the interactive here but they really are making that connection and taking it home with them.*
34	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *One of the things about [Invent] is that the multimedia are the interactive that have been on permanent display. We put them in a meaningful interpretation that allowed for a different way of seeing*

	those same scenes. People who remember them from their last visit are able to come back and have a bazaar experience with them. It would have been easy to just recreate that gallery and have it feel like the typical exhibition, but we didn't do that…we created something richer than the usual display.
35	Maria Isabel Garcia, The curator of The Mind Museum: *We wanted this gallery to be interactive, whole body experiences so from the focus groups we landed on How Things Work. From that point, the objectives were - we wanted children to see science is all around them, that they're connected to science and that through these sensory experiences, they have a connection.*
36	John Richardson, Design and Online Services Manager: *Trying to create a three-dimensional space that incorporates, like the children's gallery, fits in a role for all the senses to be thinking about science and the environment. So getting away from the pure, visual appreciation, the reading of content is a way to understand science. Trying to break that down a little bit, the MiniQ exhibit's the same way. Trying to create some experiences with science through objects like the water canals, the street smarts interactive, the construction even…where the power of science is not just theory.*
37	Per-Edvin Persson, Director of Heureka, the Finnish Science Centre *Intellectual and emotional benefits result from solving a task or a problem. This is important.*
38	John Richardson, Design and Online Services Manager: *Questacon's target audience is typically 8–14 years of age. That said we have developed exhibitions for 0–6 years and for general audiences. The largest audience sector that visits the Centre are school groups. Those that make the decision to visit the Centre are usually parents, guardians or teachers. Our audience, therefore, is families and school groups. Older teenagers, around 15 and above do not tend to visit as Questacon is perceived to be for children.*
39	Asger Hoeg, Executive Director of Experimentarium: *I think gesamt experience in science centre concept is new. I haven't read it anywhere and I came up with the idea…I see the merged of the cultural institution where they actually steal the concept from each other and then I thought…why don't we steal from all the cultural institutions from Art museum, Solatical Garden, Aquarium...so that is the basic of the idea.*

40	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *Younger people, they liked the diversity, they're curious about the new discoveries. So this was a group, we thought, they have an emotional connection to the new science discoveries that we can tap into.*
41	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *We make our exhibitions look current and relevant. Some of the ones that we've done, the Genome was definitely different kind of decision to bring in younger adult crowd. We have another The Bugs Return coming up that was partly to get our immersive exhibition out there.*
42	John Richardson, Design and Online Services Manager: *Older exhibitions are replaced by new topics can address areas of topical interest and potentially engage new audiences and encourage return visitation. Developing new exhibitions allows the opportunity to explore new methods and techniques in exhibition and exhibit design as well as employing contemporary materials and fabrication processes, plus contemporary design styling and graphic design to promote relevance and currency to increasingly design-aware audiences.*
43	Asger Hoeg, Executive Director of Experimentarium *Now we want to make our visitor giving social situation. We have an exhibit at the Experimentarium, the crane where they had to work together to make it move in the right direction…perhaps it's the most popular exhibit there because it makes the possibility of social situation.*
44	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *We have in our permanent galleries more family-friendly exhibits and we have the flexibility and the opportunity with our temporary shows (Candy) to do something that more focused on smaller children. They may not appeal to all audiences.*
45	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *I think it's important that the exhibits present a variety of points of view and a variety of kinds of experiences. Not everybody likes the same kinds of things. Not everybody responds to the same kind of exhibit so we can have different exhibits that appeal to different audiences.*
46	John Richardson, Design and Online Services Manager: *Accessibility is important. We try to make our exhibits a place for everybody…wheelchair users and so on. We try to provide an exhibit that gives a good experience to all.*
47	Cindy Chambers, Head of Concepts and Education at Questacon: *At the Q Lab gallery 4 – the big circular bench at the middle of the room, John's team deliberately had different height of bench so one end at wheelchair and child height and the other end is for the adult height. Very much detail has been considered.*

48	John Richardson, Design and Online Services Manager: *The main focus is to create a contrast on focus. It is more about the senses. If our exhibits are unique, we have to design it to be much fun to touch and explore. We are always limited by budget where kids who have hi-tech games at home, this technology have so much more funding. How do we come up with something- that's a one off built for an exhibit which will compete, so we have to do something different? So we have to find that difference.*
49	Maria Isabel Garcia, The curator of The Mind Museum: *Laughter is part of our centre experience. Any given day you come in and you hear children have fun; you have engagement between adults and kids. here is a place where kids are having that sort of experience with science.*
50	Maria Isabel Garcia, The curator of The Mind Museum: *Acknowledging the audience and limiting the amount of content common practice. The quantity of text and the vocabulary chosen and the sort of superiority conveyed in an exhibition should be simple and easy to understand.*
51	Cindy Chambers, Head of Concepts and Education at Questacon: *Our goal is to create programs that reach out to remote communities and by diverse, I mean various places across Australia. This can provide a means to reach schoolchildren who may not otherwise feel connected with Questacon.*
52	Cindy Chambers, Head of Concepts and Education at Questacon: *It is a way of finding a voice for them in this institution. The experience allows for flexibility and change and an ongoing commitment that we would like to reach out to.*
53	Maria Isabel Garcia, The curator of The Mind Museum: *Makes them want to know something, to care about the subject, to care about themselves and their relationship to it, then they're open and receptive. And then, of course…the exhibits themselves, how you place the exhibits, relationship of exhibits to one another.*
54	John Richardson, Design and Online Services Manager: *The Director of Questacon and the Science Manager propose new exhibition topics and broadly what and when these should be delivered. The Capital Exhibition Plan is adjusted to incorporate new exhibition proposals with reference to the budget position and the ECI. This is managed by the Exhibitons, Digital and Capital Programmes section*

	(EDCP). Once agreed an exhibition schedule and budget are established and this is managed by the Project Managers within EDCP.
55	John Richardson, Design and Online Services Manager: *The Design team develops and refines the ideas and resolves them into final scale 3D designs using CAD software. This is the phase that the final form of the exhibition and exhibits and the visitor experience is resolved. Working with a range of internal and external technical specialists the designers resolve and specify the wall and floor treatments, lighting, colours, materials, finishes, fabrication techniques, ergonomics and circulation, graphic design solutions and integration among other parameters.*
56	John Richardson, Design and Online Services Manager: *Engineering drawings and details are resolved and fabrication is undertaken either in-house or is outsourced depending on what is required. The Production team specialises in the fabrication of exhibit mechanisms, in developing and building electrical requirements and programming computer interactives. Items or that cannot be produced internally, or there are not enough resources to complete internally, are outsourced.*
57	John Richardson, Design and Online Services Manager: *As funding is reduced, the pressure to raise admission costs increases. With increased admission costs as well as competing forms of entertainment visitor expectations increase thereby placing additional strain on resources to deliver fun, engaging and safe experiences and their maintenance.*
58	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *A medium sized SC has operational budget of the order of USD5m. This could be on the high side. But to have such an operational sum then the SC has to have substantial backing. This is often Government and/or local funding sources. However very few SC's have the 'luxury' that museums often have whereby they are a regular item in the budget and receive an annual grant. SC's have rarely gotten that status. Singapore SC is an exception. The Government there is very supportive of the SC. PETROSAINS also is favoured by funding from PETRONAS. To be fair CEO Tengku Nasaria has to fight hard each year for a budget but as the years have progressed the sum has more or less become an item in PETRONAS budgeting.*
59	John Richardson, Design and Online Services Manager:

	We are conscious of the technology and entertainment options that are readily available to the public that, due to budget, timeframe and resources, we are not able to directly compete with.
60	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *medium and larger sized SC will have or will seek a budget for new exhibits or even for an exhibition that is typically 20 – 25 exhibits. They may also seek a budget or a strategy for receiving a 'travelling exhibition'. Typically in the US a SC will take one or even two or three travelling exhibitions a year. These can be expensive at more than USD35K /month plus the travelling and marketing costs.*
61	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *Many SC's will have a person whose job it is to find sponsors for exhibitions. When successful then the sponsor will often wish a say in the theme, the look, the overall product and so the SC often has to compromise depending on their status and success in their location. It is rare that a SC can get funding that has no strings…..such that the SC can develop and exhibition that it feels is appropriate for their scheduling.*
62	John Richardson, Design and Online Services Manager: *Different teams have different perspectives with regard to exhibits and this influences priorities of exhibit and exhibition design and subsequent outcomes. Questacon aims to build experiences that can't be experienced through other media including technology available in the home or elsewhere and mobile devices although we may include those technologies where appropriate.*
63	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *A small suite of exhibits (possibly 5-8 exhibits) can most likely be offered and worked out with a sponsor for USD200 – 250K. A full exhibition these days will cost anything from USD800 – 2+million. Indeed when working on a full exhibition space that is 300 sq m and more many fabricators and designer companies will these days quote on a per sq m basis. This then will include exhibits in an environment so that exhibits are displayed in 'attractive and appropriate' settings.*
64	Geoff Snowdon, Director Creative Design at Team Aranda Sdn Bhd: *In the US and in Australia (to a limited extent): groups of SC's have planned exhibitions together. Eg x5 SC;s might each contributed USD250K and then each take on responsibility for developing a suite of exhibits that come together representing each SC contribution. Each SC then receives the exhibition for e.g. 6 months giving a 2.5 to 3 yrs for the exhibition to satisfy all the obligations. Then they can seek profit by*

	allowing the exhibition to be listed as a travelling exhibition from which they each receive some payback. *Another model that was introduced by The Exploratorium under the previous Director Dr. Goery Delacote involved developing suites of x25 exhibits to individual themes, an education and a marketing package, training etc were all included. The participating receiving centres paid up front USD5-15K to have the exhibits for 6 months. They were then guaranteed a new exhibition each 6 months over a period of 2-5 yrs. These were small SC's the size of a school hall or small community pavilion. They could operate with 3-5 staff. This was quite a popular model but in many ways did depend a deal on the creditability of those driving the programme.*
65	John Richardson, Design and Online Services Manager: *Very often, rather than exhibit concepts being developed at the curatorial level and proposed up and approved, we very often have things just brainchild, so that actually is typical… It's not uncommon at all. If you look at our exhibit calendar, now you see…the stuff we've done primarily has been top down rather than bottom up.*
66	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *I think somehow we tried to avoid fallen behind, we have a three-year development schedule. And, so for the entire time that I've been here, we are constantly rushing. … We're constantly struggling …There's not enough time, …you're working towards the next opening … and so all your resources are being challenged to get to that next opening.*
67	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *The physical constraints of the space can hold the exhibit design to a certain level - everything from power restrictions within the space, which impacted a lot of what we could do. Again the physical layout of the space ended up dictating quite a bit.*
68	Maria Isabel Garcia, The curator of The Mind Museum: *It's the designer who has to take the materials and the story line and start to imagine what it could or should look like, and what it can do. And then it is really much of a back and forth, and it's a collaborative effort. There has to be a lot of give and take. It's very labour intensive.*
69	Daniel Tan, Director Exhibitions Group at Science Centre Singapore: *Once the actual overall design was determined, then I think that it was much easier because then you were working much more with specifics. A lot of times it was the designer who was deciding what was going to go in and what wasn't.*

APPENDIX X
SUMMARY OF CODING ANALYSIS FOR IN-DEPTH INTERVIEW

Participant 1 - John Richardson, Design and Online Services Manager

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
On the interrelation of the exhibition design, theme and the audience	Modulate different experiences is applied. The way all elements interact impacts how an exhibition will be received	*Making personal connections*
Comments on getting through to visitors at a personal level	Making the visitor experience themselves in the centre and understand about what they do is critical to unlocking an opportunity to encourage personal connections.	*Taking science home*
Describing on how the flow of an exhibition impacts the comfort and accessibility of the exhibition	Careful planning and providing wayfinding cues in the exhibition space minimize the physical, emotional, and cognitive efforts required by a visitor to navigate through the space.	*Making science accessible*
How tactile and sensory experiences makes science more readily accessible	One key design objective for the gallery was to help visitors access the content. Instilling a sense of relevance can reinforce the creation of connections.	*Making science accessible*
Comments on getting beyond the surface of the exhibition - delving into the context and the concept that the exhibition reflects	Providing young visitors, the opportunity to be directly involved with an exhibit and make a personal connection between the exhibit and their own lives can lay the groundwork for learning.	*Creating Interest by Engaging with Sensory Experience*
Explained on how the exhibits were prefaced with extensive research and planning in order to address children and	Reaching family units was at the heart of the exhibitions. The design team conducted research and focus groups to get into the minds of children	*Providing Family-Friendly Experiences*

families as a broader audience segment	and family groups to determine how to best reach them on multiple levels	
Comments on Questacon Technology Learning Centre (QTLC) and family-friendly exhibitions	Including permanent exhibitions designed toward a profile that matches with a younger audience subset would likely draw children and families, but not necessarily be limited to that particular audience segment.	*Providing Family-Friendly Experiences*
On the aspects of an exhibition design scale and proportion to deliver a message	How the message is conceived physically all play into designing the message that will be received. The targeted audience for a particular exhibition is an important consideration for the Museum relative to the design.	*Preparing to Deliver a Message*
Describing the end goal of design in an exhibition space	Although the exhibition design is built on details, the overall look and feel created by the combination of those details is what sets the scene for visitors to enter an exhibition ready to interact with the space and walk away with new information.	*Setting the Scene*
On finding the best way to intermix the subtleties of an exhibition	The interplay among energized spaces and how the contemplation spaces relate to the information presented are critical in communicating content to visitors.	*Designing a Whole through the Parts*
On collaborating skill and expertise from design team members	Designing for objects in an exhibition environment requires the team to collaborate certain sets of graphic and technical skills	*Effective Collaboration*

Participant 2 - Daniel Tan, Director of Exhibition at Science Centre Singapore

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
On providing a welcoming environment and variety for visitors	The overall array of experiences available in the centre is important in making visitors feel they can explore, access, and learn from the exhibitions within.	*Making science accessible*
Describing several examples of areas which pique visitor interest	Familiarity allows the centre to pose more detailed information and help visitors learn new things and deepen their personal connection with the content and science wonders.	*Providing Relevance by Drawing on Personal connections and the Social Environment*
Comments on an exhibition to create new awareness and find new connections by building on familiar context:	The exhibition carries a sense of layering message not just in terms of content, but because of being on display as a market stage. Interacting with an exhibition on multiple sensory levels can add depth to a visitor's experience.	*Creating Interest by Engaging with Sensory Experience*
Describing a target to a wider range of audience segments	Since the scope of audiences has expanded to the core segments, the centre's effort to connect with these new visitor groups has expanded as well	*Targeting a Range of Audiences*
On the audience interests in connecting with new aspects of science	Given the potential draw of this younger audience segment, the SCS made a deliberate effort to infuse their exhibitions with topics and design elements that might appeal to younger, prospective visitors	*Targeting a Range of Audiences*
Comments on how SCS tries to attract a younger crowd	Although perhaps not always successful in all instances, SCS aims to attract different	*Targeting a Range of Audiences*

	audience segments by rotating the exhibitions on display	
On the reasons of variety in exhibits	Different visitors respond to the different kinds of exhibitions. Identifying which audiences, the centre wants to reach and deciding to broaden the exhibition scope to appeal to those audience segments is the first step in drawing new visitors	*Targeting a Range of Audiences*
Comments on challenges with design and developing exhibitions	Defining and reaching the "family audience" posed a prolong challenge, since SCS had always placed much focus on that audience segment. Constant efforts were made to better understand and reach families	*Targeting a Range of Audiences*
Describing the importance of conveying a sense of multiplicity through variety	Different topics, different approaches, and different perspectives - breadth in all these respects serves not only to offer variety in the type of exhibition, but sends a message to visitors about the value the SCS places on supporting different preferences	*Establishing an Inclusive Environment*
Described the need for the integration of exhibition elements	Unification and integration are required to convert a gallery of objects, images, and exhibition elements into a unique space. Part of the design challenge is finding ways to make all the pieces work well together and contribute to the whole	*Designing a Whole through the Parts*
Expressed variety and layering of opportunities as strengths	The layering of all individual design components contributes to the strength of the whole	*Providing Layers of Information*

Participant 4 -Curator Maria Isabel Garcia

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
Defines ideas relative to the institution's core purpose	Make connections derived from their own personal curiosity	*Making personal connections*
Comments on the impact of an interactive exhibits to visitors	A pre-existing personal experience with an object can lead to exploration of the object label, as well as promote further involvement with the surrounding exhibition components.	*Providing Relevance by Drawing on Personal connections and the Social Environment*
On exhibition as a space to engage sensory experiences and elicit connections with science application	How Things Work engages visitors by providing the opportunity to do something related to science application - helping visitors connect with the concept	*Creating Interest by Engaging with Sensory Experience*
Comments on how the hands-on nature and the varieties of exhibits stations contributed to the success of these exhibitions with school groups	By having the opportunity to interact with the exhibitions students are creating foundations for future connections and learning	*Creating Interest by Engaging with Sensory Experience*
On Visitors invitation to science and see the connections through aesthetic space	Helping visitors leave the museum with new connections relies upon the museum knowing who its visitors are & understanding why they came	*Creating Interest by Engaging with Sensory Experience*
Comments on visitors having fun and the overall atmosphere of the Museum	The science centre is infused with energy due to the designed hands-on exhibitions which provide visitors the opportunity to laugh and enjoy themselves at the centre.	*Providing Family-Friendly Experiences*
On finding ways to make connections in emotional interest through museum experience	The concern for audience and reaching them emotionally must come first. If they are not interested, nothing they see around them will make an impact or generate a connection	*Establishing an Inclusive Environment*

Comments on descriptive titles to elicit personal interest	Exhibition titles are important - they can serve to introduce the topic, set the overall theme, and provide visitors with enough insight to the message behind the exhibition to draw them into the museum.	*Preparing to Deliver a Message*
Describing the selection of design elements for visitors' comfort and familiarity	The Mind Museum seeks to carefully chose and align the specifics of an exhibition design with their target audience(s). The designers hope to combine design details that will speak to visitors	*Preparing to Deliver a Message*
Comment on the physical space impact on people	The layout, visual appeal, and feel of an exhibition space set the scene to immerse visitors in a transformative experience. The overall impression of an exhibition space needs to make an impact to draw in visitors and make them want to see more	*Setting the Scene*
Comment on the tone of academic superiority in exhibition content	Museums overall have a more audience-centered, democratic voice. A shift in perspective toward an audience focus is implemented. It is an underlying focus for all materials designed for public interaction.	*Establishing an Inclusive Environment*
Describing integration of labels to the accessibility of content	Labels are important - information they convey and the way they are written. Length, type size, style, format, and vocabulary should be addressed relative to the targeted audience	*Making Science accessible*
How the physical space effect to the emotional connection	Creating a whole aesthetic experience is what will leave a lasting impression on museum visitors.	*Setting the Scene*
Comments on visitor designed experience	A designed exhibition experience is shaped by the integration of all the parts. This kind of integration should result in a fluid exhibition design, immersive.	*Designing a Whole through the Parts*
On the interconnection between all the design elements	The individual design elements carry weight and importance of their own, but they also should	*Designing a Whole through the Parts*

	contribute to the larger complete experience	
Comments on team approach for developing exhibitions	The dynamics and relationships between team members form the foundation for producing a wide-reaching end product	*Effective Collaboration*
Describing on the dedication of the team members	Sharing enthusiasm and expertise can trigger collaborative advances and serve as a motivating factor to push the project forward	*Partnership venture*
On collaborative arrangement with a partnership venture	Creating reciprocal agreements with other science centre is an easy way to get mutual support. Forming connections with other centres can also lead to sharing ideas, resources, programs and best practices - which can ultimately result in positive growth across institutions	*Partnership venture*

Participant 6 - Fiona Blades, Exhibition Designer at The Powerhouse Museum

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
Comments on museum scholarly notions and visitors' informal perspective	Most visitors come for leisure or entertainment, not as an academic venture. The staff needs to be conscious of what visitors hope to get out of their visit	*Targeting a Range of Audiences*
Explained on the importance of having different target audiences for different exhibitions	Distilling down exhibitions so they are appropriate for everyone is not always advantageous. Rather, designing different exhibitions for different audiences can serve to challenge all visitors to see from different perspectives	*Establishing an Inclusive Environment*
Describing design criteria vary depending on the target audience	Knowing your audience is important; designing an interesting museum experience specifically for your audience is even more important	*Establishing an Inclusive Environment*
Comments on the design as an important part of the message	The way an exhibition is designed should reinforce the message and content behind it. The objects, colors, and path through an exhibition are most effective if selected for reasons which support the idea they are striving to tell	*Preparing to Deliver a Message*
Describing the importance of an engaging physical exhibition space:	Although the Museum offers unique experiences, it must compete for visitors with other leisure activities, including movies, gaming, and other venues with high-end, interactive technology experiences	*Setting the Scene*
Comments on a well-designed exhibition	Separate exhibit pieces must support the whole and the design must fit the content. If designed well visitors will not focus on the design or the	*Designing a Whole through the Parts*

	combination of pieces, but they will appreciate the content and be drawn into the cohesive exhibition experience	
Describing on how connections are possible through variety	the Museum offers exhibitions with variety on multiple levels - in the kind objects displayed, the sensory experiences provided, the layers of information presented, the learning styles implemented, the types of media utilized, and the levels of interactivity afforded to visitors	*Providing Layers of Information*

Participant 7 - Cindy Chambers, Head of Concepts and Education at QTLC

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
In describing social recreation education in science centre	If science content is presented that affords visitor's curiosity, it promotes a connection and make science understanding more fun.	*Taking Science Home*
On accessibility and making connections with exhibitions content	This off-loading of required resources allows the visitor to be able to direct more attention to the content, making it more accessible and easier to consume	*Making science accessible*
Describing experiential learning through different styles of exhibits	Some connections may be preferable depending on the topics for different style of exhibits. Visitors need a little variety and support to access the connections.	*Making science accessible*
Comments on experiencing the exhibits	If a visitor can feel a real piece of science and be part of it then the experience becomes more tangible, more personal and heightens the connection to the theory behind it.	*Creating Interest by Engaging with Sensory Experience*
Describing science centre immersive exhibits	Learning is not necessarily the targeted goal of an exhibit, but it can be a byproduct of the experience. The hope is that visitors will make personal connections during their hands-on experience and take home with them a bit of science.	*Creating Interest by Engaging with Sensory Experience*
Comments on how the team tries to accommodate younger crowds	The team sought to understand ways to weave physical, visual and science connections into a social museum experience for children and family groups	*Providing Family-Friendly Experiences*
Describing entertainment and fun as part of a museum experience	Visitors should enjoy their time at the science centre. When people are enjoying their visit by interacting with the exhibition and each other, it	*Providing Family-Friendly Experiences*

	strengthens all the connections they are making - emotional connections with the scientific content, intellectual connections with their existing knowledge set, and social connections with the others in their group and other visitors	
Comments on programs offered in terms of broadening the museum's audience base and reaching new visitors	Involvement in programming may not result in more new walk-in visitors but offering a variety of programs is likely to encourage interest and connections with science and Questacon	*Establishing an Inclusive Environment*
On connecting new communities by acknowledging their interest	Every community, every subset of the population, should be inclusive through science programs and travelling exhibition tour in Australia	*Establishing an Inclusive Environment*
Describing exhibitions as pushing the boundaries of learning	Museum exhibitions have the potential of being immersive environments that bring ideas and science to life. The space in a science gallery can be designed to temporarily transport visitors to another time and place	*Setting the Scene*
Comments on integrating technology into the Questacon	Using technology in the Questacon was important to draw and engage certain audiences. Technology was included as a design element that would make the exhibition interaction more conducive to helping visitors make connections with science	*Setting the Scene*

Participant 9 - Matthew Connell, the Principal Curator of Physical Sciences and IT at the Powerhouse Museum

What are the methods to enhance visitors' level of engagement on the experiential settings?
How does science and technology museum create meaning and cultivate connections in their practice?

Comments on	Interpretation	*Theme*
Comments on people seek out connections based on their life and personal experiences	Personal details can prompt visitors to make connections. Helping visitors connect with exhibitions on a personal level can trigger questions; asking questions can lead to gathering new information; new information can result in having visitors leave the exhibition with a new personal connection with science. It's the immersive experience itself	*Providing Relevance by Drawing on Personal connections and the Social Environment*
Comments on design exhibitions and the general audiences	The Powerhouse Museum and its exhibitions should be developed to attract people who will be motivated to visit and connect with what they see.	*Targeting a Range of Audiences*
Comments on the challenge of designing in anticipation of the visitor's needs	The connection a visitor makes in an exhibition is more than about tailoring the content to meet visitor needs. The topic in the exhibition may spark interest or an initial emotional response, but the entire exhibition design and elements must be considered relative to the target audience	*Establishing an Inclusive Environment*
Describing the design process as critical in addressing exhibition variations	Presentation matters. Good design or bad design can make or break an exhibition; design can promote an evocative experience for visitors or crush the potential to help visitors connect with meaningful content	*Designing a Whole through the Parts*
Comments on the design role in providing visitors with a rich exhibition experience	The design must unify the content, objects, and exhibition elements in a comprehensive	*Designing a Whole through the Parts*

	and powerful way in order to reach visitors	
Describing the challenge of creating an exhibition experience which reaches visitors of various backgrounds:	Merging elements to create a cohesive exhibition is difficult and requires careful consideration regarding the target audience. The parts of an exhibition must be assembled to generate a powerful and meaningful whole. The design team must consider the variety of visitors who may pass through the exhibition	*Designing a Whole through the Parts*