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**The Physical Context of Hands-on Interactive Museum Exhibits : Identification and Categorization of
Pedagogically Relevant Concepts**

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**The Physical Context of Hands-on Interactive Museum Exhibits:
Identification and Categorization of Pedagogically Relevant Concepts**

Thomas Hillman

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Abstract

Many options are available to designers when creating museum exhibitions. One particular option that can be chosen is the inclusion of exhibits that can be touched and manipulated, a style of exhibit often referred to as hands-on or interactive (Adams and Moussouri, 2002). Within this subset of exhibits, designers also have a multitude of choices to make that can affect the experiences visitors will have. The goal of this study is to help the transfer of research findings about learning and hands-on interactive exhibits to designers so that more-informed choices may be made. With this goal in mind, the exhibits within three exhibitions at the *Montreal Science Centre* are examined from a pedagogical perspective. Falk and Dierking's *Contextual Model of Learning* (2000) is employed as a conceptual framework, and one of its contexts is specifically addressed. Since exhibition designers act upon the objects that form exhibits, and only have direct influence on their physical nature, the *physical context* of Falk and Dierking's model is chosen as a lens through which to investigate the exhibits. Emergent concepts from the *physical context* of those exhibits are collected and then categorized. To relate the emergent concepts to a pedagogical perspective, the categories are then associated to the *pedagogical triangle* (Houssaye, 1988; Moore, 1989), which allows them to be organised following the roles and interactions present in that model. This study, therefore, presents a structure and common language through which the *physical context* of hands-on interactive museum exhibits can be understood from a pedagogical perspective.

Table of Contents

Acknowledgments.....	i
Abstract.....	ii
Table of Contents.....	iii
Table of Figures.....	vii
Introduction.....	1
1. Literature Review.....	4
1.1 Historical Development of Museums.....	4
1.2 Development of Hands-on Interactive Learning in Science centres.....	6
1.3 Comparison of Hands-on Interactive Exhibits with Traditional Static Exhibits as Visitor Experiences.....	9
1.4 Exhibition Design, Learning Technologies and Visitor Learning.....	13
1.5 Research Questions.....	17
1.6 Conclusion.....	18
2. Conceptual Framework.....	20
2.1 Pedagogical Triangle.....	20
2.1.1 Roles Within the Pedagogical Triangle.....	21
2.1.2 Interactions Within the Pedagogical Triangle	22
2.2 Extension of the Pedagogical Triangle.....	25
2.3 Contextual Model of Learning.....	27
2.4 Operational Definitions.....	29
2.5 Synthesized Conceptual Framework.....	30
2.6 Conclusion.....	32
3. Methodology.....	33
3.1 Setting.....	33
3.1.1 Montreal Science Centre.....	34
3.1.2 Eureka!.....	36
3.1.3 X-Treme Rotation.....	39
3.1.4 Technocity.....	42
3.2 Data Collection and Pre-Analysis.....	44

3.3 Analysis.....	48
3.4 Validity and Reliability.....	49
3.5 Conclusion.....	50
4. Findings.....	51
4.1 Content Categories.....	51
4.1.1 Content Delivery Mode(s).....	53
4.1.1a Audio.....	54
4.1.1b Tactile.....	54
4.1.1c Olfactory.....	55
4.1.1d Moving Image(s).....	55
4.1.1e Text.....	56
4.1.1f Still Image(s).....	57
4.1.2 Content Representation(s).....	58
4.1.2a Demonstration.....	58
4.1.2b Analogy.....	59
4.1.3 Physical Access to Interface(s).....	60
4.1.3a Constrained.....	60
4.1.3b Open: Interface(s) can be approached from multiple sides.....	60
4.1.3c Open: Interface(s) can be shared by multiple users.....	61
4.1.4 Physical Mechanics of Exhibit.....	62
4.1.4a Static.....	62
4.1.4b Dynamic: Mechanical.....	63
4.1.4c Dynamic: Analogue Electronic.....	63
4.1.4d Dynamic: Digital.....	64
4.1.5 Physical Interface(s) of Exhibit.....	65
4.1.5a Soft.....	65
4.1.5b Hard: Electronic Control(s).....	66
4.1.5c Hard: Mechanical Control(s).....	67
4.1.5d Hard: Direct Manipulation.....	67
4.2 Learner Categories.....	68
4.2.1 Visitor Sense(s) Implicated.....	69
4.2.1a Vision.....	70
4.2.1b Hearing.....	70
4.2.1c Touch.....	71
4.2.1d Smell.....	72
4.2.1e Balance.....	72
4.2.2 Necessary Visitor Number(s).....	73
4.2.2a Single.....	73
4.2.2b Plural: Cooperative.....	74
4.2.2c Plural: Competitive.....	74
4.3 Content – Learner Interaction Categories.....	75

4.3.1 Task Activity(s).....	77
4.3.1a Question & Answer.....	77
4.3.1b Exploration.....	78
4.3.1c Investigation.....	78
4.3.1d Observation.....	79
4.3.1e Creation.....	80
4.3.2 Task Path(s).....	80
4.3.2a Open.....	81
4.3.2b Pre-Defined: Single.....	81
4.3.2c Pre-Defined: Multiple.....	82
4.3.3 Task Outcome(s).....	83
4.3.3a Open.....	83
4.3.3b Pre-Defined: Single.....	83
4.3.3c Pre-Defined: Multiple.....	84
4.5 Conclusion	87
5. Discussion.....	88
5.1 Discussion of the Conceptual Framework.....	88
5.2 Discussion of the Content Categories.....	89
5.2.1 Content Delivery Mode(s).....	90
5.2.2 Content Representation(s).....	91
5.2.3 Physical Access to Interface(s).....	92
5.2.4 Physical Mechanics of Exhibit.....	93
5.2.5 Physical Interface(s) of Exhibit.....	94
5.3 Discussion of Learner Categories.....	94
5.3.1 Visitor Sense(s) Implicated.....	96
5.3.2 Necessary Visitor Number(s).....	97
5.4 Discussion of Content – Learner Interaction Categories.....	97
5.4.1 Task Activity(s).....	98
5.4.2 Task Path(s).....	99
5.4.3 Task Outcome(s).....	99
5.5 Conclusion.....	100
Conclusion.....	101
Contributions.....	102
Limitations.....	104
Further Research.....	105
References.....	107

Appendix A.....	113
Montreal Science Centre Profile Web Page.....	113
Montreal Science Centre History Web Page.....	115
Montreal Science Centre Eureka! Web Page.....	117
Montreal Science Centre X-Treme Rotation Web Page.....	118
Montreal Science Centre Technocity Web Page.....	120
Appendix B.....	121
Appendix C.....	122
Eureka! Floor Plan.....	122
X-Treme Rotation Floor Plan.....	123
Technocity Floor Plan.....	124
Appendix D.....	125
Categorization Process Examples.....	125

Table of Figures

Figure 1: Pedagogical Triangle (Houssaye, 1988).....	21
Figure 2: Pedagogical Triangle (Moore, 1989).....	21
Figure 3: Pedagogical Triangle (Anderson and Garrison, 1998).....	25
Figure 4: The Contextual Model of Learning (Falk and Dierking, 2000).....	27
Figure 5: Synthesized Conceptual Framework.....	31
Figure 6: Outside Montreal Science centre.....	35
Figure 7: Overall Floor Plan (Montreal Science centre, 2006).....	36
Figure 8: Eureka! with windows to outside.....	37
Figure 9: Glass wall with artifacts.....	38
Figure 10: X-Treme Rotation.....	39
Figure 11: Rotoscopic Machines by Bill Vorn.....	41
Figure 12: Technocity with simulated production line.....	43
Figure 13: Content Categories.....	53
Figure 14: Speaking Volumes.....	54
Figure 15: Building Blocks.....	55
Figure 16: The Nine Little Pigs.....	55
Figure 17: Quiz Cuisine.....	56
Figure 18: Health Foods, Fact or Fiction?.....	57
Figure 19: To Each Job Its Lever.....	57
Figure 20: Who's Up For a Spin.....	58
Figure 21: A Real Head Turner.....	59
Figure 22: My House Is My Cocoon.....	60
Figure 23: Flattering Physics?.....	61
Figure 24: Nailing The Challenge.....	61
Figure 25: Maximum Amplitude.....	62
Figure 26: Frrrrrriction.....	63
Figure 27: Hop In The Saddle.....	64
Figure 28: You've Got The Power.....	64
Figure 29: Biped Born Bald.....	66
Figure 30: The Digital Revolution.....	66
Figure 31: Get The Wheels In Your Head Turning.....	67
Figure 32: The Aluminum Reed.....	68
Figure 33: Learner Categories.....	69
Figure 34: Cyclorama.....	70
Figure 35: Riding a Radio Wave.....	71
Figure 36: Fakir School.....	72
Figure 37: Tightrope Walker.....	73
Figure 38: Invisible Chefs.....	74
Figure 39: Talking Saucers.....	74
Figure 40: What's For Supper?.....	75
Figure 41: Content - Learner Interaction Categories.....	76

Figure 42: Chameleon Houses.....	77
Figure 43: Tornado Simulator.....	78
Figure 44: Deposit Detection.....	79
Figure 45: Take a Look at a Chip Under a Microscope.....	79
Figure 46: Creation in Motion.....	80
Figure 47: Higher and Higher.....	81
Figure 48: Into The Gene Pool.....	82
Figure 49: The Macro Microphone.....	82
Figure 50: A Question of Balance.....	83
Figure 51: Pitch In.....	84
Figure 52: Trace That Call.....	84
Figure 53: Synthesized Schematic Diagram.....	86

Introduction

This thesis examines, from a pedagogical perspective, the physical context of the hands-on interactive museum exhibits found within three exhibitions at the *Montreal Science Centre*. The objective of this research is to gain a greater understanding of the physical nature of such exhibits in relation to visitor learning experiences. It is hoped that this knowledge will not only open avenues for further research, but also aid museum exhibition designers when creating future learning opportunities. In recent years, hands-on interactive exhibits have become fashionable in many museums and science centres. Among the earliest types of institution to develop such exhibits, science centres constituted an entire class of museum-like facilities dedicated to hands-on interactive experiences (Butler, 1992). Since the first science centres opened in 1969, namely, the *Exploratorium* in San Francisco and the *Ontario Science Centre* in Toronto, hands-on exhibits have provided an experience for visitors distinct from that of the more traditional artefact and text style formats. Especially in the subject areas of the physical sciences, it has since become popular to engage visitors in learning through science centres instead of with more traditional artefact-based science museums (McManus, 1992). Between 1969 and 1996 several hundred such centres opened in the United States, 33 in the United Kingdom, 31 in Scandinavia, 12 in Spain, ten in the Netherlands, and six in France (Persson, 1996). By 2006 in Canada more than 10 centres had opened, including: Ontario Science Centre, in Toronto; Montreal Science Centre; Science World, in Vancouver; Science North, in Sudbury; and Telus World of Science, in Edmonton. This use of hands-on exhibits has not been limited to purpose-built science centres and is now common in more traditional museums, often along side static artefact based exhibits.

Following the increased use of hands-on interactive exhibits, research has increased, particularly about the understanding of how such exhibits function to effectively meet the goals of museum and science centre staff (Allen, 2004). These goals most often include providing an environment of learning opportunities with a wide variety of experiences (Butler, 1992). Despite this breadth of research on learning and hands-on interactive exhibits, a lack of a common language and taxonomy, makes situating existing and new research on individual concepts within the greater hands-on interactive exhibit learning experience difficult. This difficulty impedes the transfer of that research to practice.

Since hands-on interactive exhibits are objects designed expressly with learning in mind, their physical nature dictates much about the learning experiences they foster. Falk and Dierking's (2000) *Contextual Model of Learning* divides informal learning experiences, like museums, into three contexts: *personal*, *social* and *physical*. In the case of exhibits in science centres and museums, the *physical context* refers to that part of a learning experience that is manifested by the object of the exhibit. The examination of that context helps to facilitate the analysis and comparison of exhibits, and perhaps more importantly, to transfer the findings of research to the practice of exhibition design. It is from the need for greater understanding, particularly in relation to the *physical context* of exhibits, that this study developed. Its purpose is to investigate the *physical context* of hands-on and interactive museum exhibits from a pedagogical perspective. With this purpose in mind, the identification and categorization of the emergent concepts from the hands-on and interactive exhibits found within three exhibitions at the *Montreal Science Centre* is undertaken.

The first chapter of this thesis situates the examination of hands-on interactive exhibits from a pedagogical perspective. A historical context for public education in museums is presented, followed by a discussion of the development of hands-on interactive exhibits in science centres. Then, research on visitor learning is examined, and the research questions that anchor this study are identified.

The conceptual framework chapter then describes the models that form the foundation for this research. Both Falk and Dierking's *Contextual Model of Learning* (2000) and the *pedagogical triangle* (Houssaye, 1988; Moore, 1989) are presented, along with operational definitions of relevant terms and concepts.

In the third chapter, the methodology employed for the study of the physical context of hands-on interactive exhibits is expounded upon. Each step in the collection and analysis of data is specified.

The fourth and fifth chapters pertain to the presentation and discussion of the findings from this study. These findings respond to the questions proposed in the first chapter and deal directly with those categories and concepts that emerge from the examination of the physical context of hands-on interactive exhibits.

Finally, the conclusion identifies the contributions and limits associated with the present study and explores avenues for further research.

1. Literature Review

In this chapter, the context for a study of hands-on interactive museum exhibits from a pedagogical perspective will be explored. This exploration will begin with the historical context of hands-on interactive experiences in museums. Then, the development of hands-on interactive exhibits in science centres will be addressed. Third, research that compares hands-on interactive exhibits with more traditional exhibits will be discussed, and finally, the effects of exhibition design on museum visitors' learning experiences will be examined.

1.1 Historical Development of Museums

The concept of hands-on interactive experiences in museums is the result of the development of museums as public institutions. Examples of museums can be found as far back as ancient Greece; however, these early museums served an archival rather than public role, often not even allowing visitors (Cameron, 1995). It wasn't until the 18th century that the modern concept of museums as places for visitors to be exposed to different objects and ideas emerged in Europe (Ibid). Museums spread across Europe between 1700 and 1800 with the opening of several major institutions that exist to this day, for example the *British Museum*, London, in 1759; the *Uffizi Gallery*, Florence, in 1765; and the *Louvre*, Paris, in 1793 (Ibid). It wasn't until the end of the 19th century that the idea of a truly public museum emerged, and with it, museums as an educational vehicle for the masses (Hill, 2005). This shift resulted in new museums, such as the *Deutsches Museum* in Munich and the *Science Museum* in London, that were committed to the idea of universal access and were predominately owned and funded by governments. The

radical change from an exclusive place dedicated to the wealth of its owners to a place for the general public occurred very abruptly (Ibid). Noted museums researcher and theorist Eilean Hooper-Greenhill views this change as a result of the ideas of the French Revolution which had directly resulted in the opening to the public of the royal collections at the Louvre (Hooper-Greenhill, 1992). After the idea had swept across both Europe and North America, new public museums developed that were democratically oriented, many of which had the specific goal of educating the working class (Ibid). Particularly in the area of science museums, a major reason for the dramatic reorientation of the nature of museums was the empowerment of an emerging middle class in Europe. The newly-wealthy industrial middle class, particularly in northern England, was essentially excluded from the predominant cultural institutions of the 19th century. Kate Hill (2005) theorises that the relatively under-exploited area of cultural institutions based on the sciences was particularly accessible to these new industrialists. She goes on to offer that public science museums provided a way for the middle classes to control a new type of culture and thus establish and consolidate for themselves a cultural identity (Hill, 2005). In the United States, the rise of the middle class in large east-coast cities mirrored the phenomenon occurring in Europe (Orosz, 1990). Museums in Boston, New York, and Philadelphia began to become more egalitarian along with the elitist organisations that controlled them. Between 1820 and 1840, the idea of popular education gained a great deal of momentum in American society and calls for the egalitarianism of museums, along with other institutions of knowledge, became increasingly strong. Organisations like the *American Academy of Natural Sciences*, the *New York Historical Society*, and the *Peale Museums* were forced to meet the growing demands for public education (Ibid).

Thus, the democratization of museums that occurred in the 19th century resulted in the inclusion of education as a major goal in museum development. Since that time, the art of designing and producing exhibitions has continually evolved. In the second half of the 20th century, museology experienced a major shift with the introduction of hands-on interactive learning as a way of shaping visitor experiences. That development will be discussed in the following section.

1.2 Development of Hands-on Interactive Learning in Science centres

Hands-on interactive learning, though now present in museums of many formats, is strongly linked to institutions that are devoted to science and technology. Since hands-on interactive exhibits must, by their nature, make use of technology to invite the participation of visitors, they first appeared in science and technology exhibitions. One of the first examples of hands-on exhibits occurred in Paris at the *Palais de la Découverte* which opened in 1937 (Butler, 1992). Initially conceived as a part of the 1937 *Paris International Exhibition*, the *Palais de la Découverte* was so popular with visitors that its founder, the scientist Jean Perrin, chose to use the temporary exhibition as the basis for a permanent centre. Where the *Palais de la Découverte* differed from the science and technology museums of its time, such as the London *Science Museum* and the Munich *Deutsches Museum*, was in the intention of its founder. Jean Perrin never intended *Palais de la Découverte* to be a museum in the strictest sense, never having the collection of objects as one of his goals. Instead Perrin stated his goals as, "...to bring to everybody's attention the progress of science and technology; to develop the scientific spirit and hence the qualities of honest criticism, of free judgement (Butler, 1992, following Danilov, 1982,

p.30)". Perrin's initial goals for the *Palais de la Découverte* were enlarged 1980 when the *Palais* became part of the large *Cité des Sciences et de l'Industrie* complex which was developed the renovation of a derelict Paris site.

Like Jean Perrin, another scientist who sought to communicate his passion for science to the public through a museum-like institution was Frank Oppenheimer. A physicist by training, he was a major pioneer in the creation of the hands-on interactive science centre as a specific type of institution. His initial concept of a place where visitors could engage in an environment of discovery has remained the basis for most science centres (Butler, 1992). During 1965, Oppenheimer, a professor in the department of physics at the University of Colorado, received a Guggenheim fellowship to work at University College, London. During his time in Europe, Oppenheimer visited many museums and was greatly influenced by the London *Science Museum*, the *Deutsches Museum* in Munich, and Jean Perrin's *Palais de la Découverte* in Paris (Oppenheimer, 1982). He was impressed by the large museums of science and technology in Europe and surprised at the lack of similar institutions in the United States. As a response, in 1968 he published a paper titled *A Rationale for a Science Museum*, in which he presented his vision of an institution that used what he called the psychology of perception as its major organising theme (Butler, 1992). This vision was realized a year later, with the opening of the *Exploratorium* in San Francisco.

Another influential institution, the *Ontario Science Centre* also opened in 1969. Where the *Exploratorium* proposed a completely new and systematic way to present physical phenomena, the contrasting objective of the *Ontario Science Centre* was to find new interpretive approaches to exhibit development within a more traditional frame (Butler, 1992).

The *Ontario Science Centre* made extensive use of hands-on interactive exhibits, but had artefacts related to those exhibits as well as entire exhibitions on such traditional themes as *Transport, Food, and Sport*. In this way the *Ontario Science Centre* was much more of an evolutionary step from traditional museums than the radical departure embodied by the *Exploratorium*.

In his development of the *Exploratorium*, Oppenheimer created an approach for museum exhibitions that remains influential in both Europe and North America (Butler, 1992). Although this development was based largely on his own anecdotal experiences, the guiding principles that were defined served as the basis for a much larger inquiry into the experience of visiting a museum (Ibid). In his paper, *A Rationale for a Science Museum*, Oppenheimer outlines his philosophy by explaining that people require apparatus which they "...can see and handle and which display phenomena which people can turn on and off and vary at will. Explaining science and technology without props can resemble an attempt to tell what it is like to swim without ever letting a person near water (Oppenheimer, 1968)". He goes on to discuss the general perception of the sciences as frightening and removed from everyday life, and indicates how a science centre could modify that perception:

"There is thus a growing need for an environment in which people can become familiar with the details of science and technology and begin to gain some understanding by controlling and watching behaviour of laboratory apparatus and machinery; such a place can arouse their latent curiosity and can provide at least partial answers (Oppenheimer, 1968)".

The educational approach that emerged from Oppenheimer's vision for the creation of hands-on interactive exhibits was compatible with that of Dewey in the way that visitors' inquiry and direct experiences of phenomena were given particular importance. It was ahead of its time in the way that it embraced what was later identified as a constructivist perspective (Allen, 2004). Indeed, Oppenheimer is recognized as being one of the first to develop a systematic process for the creation of museum exhibitions based on a theory of learning. His basic goal was to empower visitors by encouraging their curiosity instead of controlling it (Hooper-Greenhill, 1999). This is in contrast with older institutions that, as discussed earlier, developed their exhibitions without great thought for the learning experiences of visitors and took on the approach of presenting artefacts as loosely related parts of a large collection (Butler, 1992). The ideas that Oppenheimer developed with the opening of the *Exploratorium* have since been refined and developed further into an approach that goes beyond science centres and is applicable to museums in general. His legacy is the vast numbers of hands-on interactive exhibits that can be found in museums and science centres today (Allen, 2004). As the volume of such exhibits has increased, so too has the amount of research on their impact compared to more traditional exhibits. This area of research will be explored in the next section.

1.3 Comparison of Hands-on Interactive Exhibits with Traditional Static Exhibits as Visitor Experiences

Since the introduction of hands-on interactive exhibits and their wide application, research on their qualities has blossomed (Falk et al., 1985; Miles and Tout, 1991; Stevenson, 1991). As with many new developments, much of the research associated with hands-on

interactive exhibits has been comparative. Several studies have addressed the comparison of hands-on interactive exhibits with the more traditional static style from a visitors' learning perspective (e.g. Goldowsky, 2002; Persson, 1996; Tulley and Lucas, 1991). This research has addressed three key areas in particular: motivation, museum fatigue, and preconceived visitor perceptions. These areas will be discussed in the following sections.

The use of hands-on exhibits in museums has been widely acknowledged to aid in fostering intrinsic motivation amongst museum visitors (Csikszentmihalyi and Hermanson, 1995) and in the reduction of the effects of museum fatigue (Falk et al., 1985). Museum fatigue is a concept that is used in the museum design and research communities to describe the effect that manifests itself when visitors become mentally or physically tired during a visit. Miles and Tout (1991) showed that mental museum fatigue and not physical fatigue, occurs in the form of object satiation after about 30 minutes in traditional museum exhibitions. After this time, visitors stop at individual exhibits less often and spend less time when they do. In comparison, Stevenson (1991) found that visitors to the wholly hands-on interactive exhibition, *Launch Pad*, at London's *Science Museum*, showed no significant signs of object satiation during visits. Stevenson also found that children spent more than twice the amount of time with exhibits than adults did, thus indicating that the *Launch Pad* exhibition effectively engaged its primary audience: children from age six. This is at the root of the positive museum experience; "... museums, without external means to compel a visitor's attention, must rely almost exclusively on intrinsic rewards" (Csikszentmihalyi and Hermanson, 1995, p.35). Research shows that hands-on interactive exhibits aid in both fostering intrinsic motivation and in limiting the effects of museum fatigue. These properties have a major effect in shaping visitors' experiences.

Another major factor in shaping museum visitor experiences is the motivation a visitor has for visiting an exhibition and their preconceived notions about it. Any preconceived notion that a visitor has of a museum will have a direct effect on their experience (Falk and Dierking, 1992). It is particularly important for institutions to both create positive experiences for visitors and to also foster positive perceptions in the public at large (Ibid). In her large study of visitors in three UK museums with predominantly hands-on interactive content (see Table 1), Theano Moussouri investigated the perceptions of family-group visitors and identified their responses (Adams and Moussouri, 2002). In treating each of the museums as case studies: the *Museum for Children* in Halifax, the *Archaeological Resource Centre* in York, and the *Museum of Science and Industry* in Manchester, Moussouri was able to identify common characteristics from the perceptions of visitors towards hands-on and more traditional museum experiences. These perceptions are outlined in Table 1, below.

<i>Interactive</i>	<i>Non-Interactive</i>
Exciting, enjoyable Interesting way to demonstrate things Colorful Touch, feel, hold, handle Get involved, participate	Boring Keep off Look-but-don't-touch Nothing to do
Explore and play Experiment Use all senses Explainers (social interaction)	Passive Look, read labels
Appreciate, think, understand Get an insight More educational, easier to learn Learn more in different ways	Cannot absorb anything
Aimed at children Exhibits are unbreakable Children are safe here Freedom of movement Relaxing	Adult-centreed Keep an eye on the children Afraid of breaking things (behavioural and physical constraints)
Time flies (flow) Stay longer Remember (long-term effect)	Get in, get out

Table 1: Visitors' Ideas About Interactive and Non-Interactive Museums (Adams and Moussouri, 2002)

Though Moussouri indicates that many respondents in her study believed that both hands-on interactive and more traditional exhibits were important in museums, her study shows that institutions with predominantly hands-on interactive exhibits have a more positive image in the perception of family groups than the more traditional ones (Adams and Moussouri, 2002).

Particularly in the key areas of motivation, museum fatigue, and preconceived visitor perceptions, research shows that hands-on interactive exhibits are powerful alternatives to the more traditional static type. In an effort to capture and maintain the interest of visitors, museums

are finding new and creative ways to introduce hands-on content into their exhibitions. Research on the effects of exhibition design on visitors' learning experiences will be discussed in the next section.

1.4 Exhibition Design, Learning Technologies and Visitor Learning

The introduction of hands-on interactive technologies in museum exhibitions is one of the many ways in which the design of exhibitions affects visitors' experiences. The constant evolution of exhibition design means that new and reinvented ways of engaging visitors are constantly available for study. Each new type of visitor experience created by exhibition designers is supported by technological aids. Sometimes a completely new type of experience is created by a re-imagined use of existing technology and sometimes it is created with new technology, but in their essence all museum exhibitions contain technologies that support the designer's vision of the design. Since exhibitions are created with a specific education goal, the technologies used within them are *learning technologies*. Johanssen, Peck and Wilson define *learning technologies* as "...any environment or definable set of activities that engage learners in active, intentional, authentic, and cooperative learning" (Johanssen, Peck, Wilson, 1999, p. 13). A direct analogy can be made between exhibits in museums and classroom learning technologies. If exhibits are analogous to learning resources then, following Johanssen et al's definition, exhibitions are a form of *constructivist learning environment*. Exhibitions as form and content are then products of their designers, just as in Johanssen et al's definition: *learning technologies* are products of their instructional designers. As products of their designers, *learning technologies* are artifacts that reflect the expertise of those designers and are intended to

convey that expertise to learners (Johanssen, Peck, Wilson, 1999). Hands-on interactive exhibits are then seen as exemplary artifacts, indicating that they can then be viewed as *learning technologies* or as knowledge containers. In essence, hands-on interactive exhibits can be seen as an extension of their designers' vision, placed within exhibitions to create the learning experiences that, in proxy, those designers intended for visitors. Extending Johanssen et al's definition, hands-on interactive exhibits, as knowledge containers, do not possess any knowledge value in isolation; only in their appropriation and use by learners can their potential knowledge value be achieved (Ibid). In this way, hands-on interactive exhibits can be viewed as objects that have the possibility of working, in proxy for their designers and in conjunction with visitors to create learning opportunities and not as objects that contain knowledge simply prepared for transmission.

As designed objects, research on museum and science centre exhibits has shown that their design has a direct effect on visitor learning experiences (Falk and Storksdieck, 2005; Sandifer, 2003; Gilbert and Stocklmayer, 2001; Falk, 1997; Allen, 1997; Henderlong and Paris, 1996). For example, in their large study of visitors to the *California Science Centre*, Falk and Storksdieck (2005) demonstrated that several exhibition design characteristics have an effect on visitor learning. Following earlier work by Falk and Dierking (1992) and Falk (1997), Falk and Storksdieck (2005) showed that several characteristics, including the physical orientation and thematic grouping of individual exhibits, have a particular effect on visitors' interest and motivation to engage deeply in an exhibition. In a similar vein, Sandifer (2003) uncovered two particular characteristics of an exhibit's design that have an effect on holding a visitors' attention. These factors, technological novelty and open-endedness, were shown to have a positive

correlation with the amount of time a visitor spends engaged with an exhibit. Though longer engagement with an exhibit is no guarantee of learning, Sandifer argues that it is an indication of a particular exhibit's opportunity to inform.

In an effort to attain a better understanding of the effects labelling can have in exhibitions, Falk (1997) tested making an exhibit's concepts explicit through signage. Visitors' comprehension of broad concepts was tested with and without the concept signage present. Using semi-structured pre and post tests of visitors' comprehension, Falk found that, with explicit labelling of the exhibitions' different conceptual clusters, visitors demonstrated a significantly improved ability to discern and articulate major intended messages. In a similar study of exhibit labelling, Allen (1997) investigated labels specifically designed to encourage inquiry activities. In her study, Allen conducted structured interviews with 392 visitors, aged seven to adulthood, at the *Exploratorium* in San Francisco. Participants were interviewed, then asked to complete one of seven inquiry tasks related to a hands-on exhibit on shadow-creation. Finally participants were asked to complete two tasks to evaluate their understanding (Allen, 1997). An inquiry task is generally an action that visitors are encouraged to perform while engaged with an exhibit. Such tasks are often associated with hands-on interactive exhibits as they are seen to provide visitors with a set-up or orientation while they interact with an exhibit. In the case of Allen's (1997) study, the seven inquiry activities that participants were asked to perform were: generate an explanation of the phenomenon; interpret an explanation of the phenomenon; troubleshoot an explanation of the phenomenon; choose between two explanations of the phenomenon; choose, plus design, a discriminating experiment using the phenomenon; choose, plus make and test, a related prediction from the phenomenon; and make a prediction before experiencing the

phenomenon (Ibid). The inquiry activity which involved interpreting the explanation of the shadow-creation phenomenon was found most effective in facilitating visitors' understanding of the mechanism. In contrast, the prediction inquiry activity was least effective (Ibid). Both Falk (1997) and Allen (1997) showed some of the impact possible through one particular part of exhibition design, namely signage. These studies illustrate the scale of research opportunities related to exhibition and visitor learning.

Henderlong and Paris (1996) conducted a study, similar to both Falk (1997) and Allen (1997), but examining specifically hands-on interactive exhibits. In a program of research that consisted of two studies of Grade 1-6 children in predominantly hands-on museum exhibitions, they investigated the concept of partially completed exhibits and its effect on children's motivation to engage. By creating their own simple geometric puzzle-type exhibits, Henderlong and Paris tested activities with different levels of initial completion. In the first study, 120 Grade 1-6 children were observed interacting with a tangram type exhibit that started as either fully completed, partially completed, or uncompleted (Henderlong and Paris, 1996). Thus, when a participant sat down in front of the tangram activity it was either in a solved state, a partially solved state, or a completely unsolved state. Data was collected on a broad set of criteria involving the context of the participant's experience, but more specifically on the participant's stated preference for different levels of initial completion, and the final level to which the participant completed the activity during a session (Ibid). For the second study, the experiment was repeated using a different exhibit. Forty grade 1-3 children interacted with a maze-type exhibit instead of a tangram. In both studies, participants showed the most engagement with an activity when its initial state was one of partial completion. Interestingly, participants did not

express a particular preference for either the partially completed state or the fully completed state, but did express a preference for both those states over the fully uncompleted state. Participants did, however, tend to engage further in activities that were initially partially completed than in those that were initially fully completed (Henderlong and Paris, 1996).

Henderlong and Paris (1996), like Falk and Storksdieck (2005), Falk (1997) and Allen (1997), provide particularly useful insight into the design of hands-on interactive exhibits. Their study is a noteworthy example of research that can provide guidelines to designers when creating hands-on interactive exhibits that motivate visitors. There is strong support for the idea that exhibition design has a direct effect on the learning experiences of visitors (Falk and Storksdieck, 2005; Sandifer, 2003; Gilbert and Stocklmayer, 2001; Falk, 1997). This applies equally well to hands-on interactive exhibits as to more traditional static exhibits. Regardless of the type of exhibit, its design has a great deal of influence on visitors' experiences. With that in mind, the next section will present the research questions at the core of this study that relate directly to the design of exhibits.

1.5 Research Questions

The introduction of hands-on interactive exhibits has opened a large amount of research interest, both in comparing hands-on interactive exhibits to more traditional examples and in directly addressing the effects of exhibition design. Since hands-on interactive exhibits have added a vast number of approaches for designers to choose, there is a need to examine those approaches to evaluate their effects on visitor learning experiences. Such an examination would aid exhibition designers in better applying the possibilities available to them and would also

situate existing and future research. It would help to situate research on hands-on interactive exhibits within a recognizable greater body of research, thus creating an interface between the research and the practice of exhibition design. In an effort to move towards the creation of such an interface, this study proposes a structured examination of the physical context of hands-on interactive exhibits. The cornerstone of this study explores the following research question: From a pedagogical perspective, what categories and concepts emerge from an analysis of the physical context of hands-on interactive exhibits? From that question emerges two distinct sub-questions, the first of which deals specifically with the categories and concepts that emerge through the study of hands-on interactive exhibits. Examining solely the physical context of such exhibits raises the following question: What categories and concepts of hands-on interactive exhibits emerge from an analysis of their physical context? Having identified categories and concepts, a second sub-question is apparent. This question deals specifically with the examination of the exhibits from a pedagogical perspective: In light of the pedagogical perspective how are the emergent categories and concepts organised? These questions serve as the core of this study and are addressed in each phase of its development.

1.6 Conclusion

The research questions presented above are drawn from the context outlined in this chapter. This context has been developed from the historical situating of hands-on interactive experiences in museums; the development of those experiences into learning experiences within science centres; the comparison of hands-on interactive exhibits with more traditional exhibits;

and finally, the relationship between exhibition design as the creation of learning technologies, and museum visitor learning. The questions drawn from that context will be conceptually framed for the purpose of their investigation in the next chapter.

2. Conceptual Framework

To frame this study, two models are used. The first one, the *pedagogical triangle* (Houssaye, 1988; Moore, 1989), is used to organize the complex local set of interactions that emerge as concepts and categories in the study of hands-on interactive exhibits. This model is then augmented by Anderson and Garrison's (1998) extension that is of particular relevance to this study. The second model, the *Contextual Model of Learning* (Falk and Dierking, 2000), serves as a lens for analysis of the global context of the local interactions. After discussing these models, key concepts are operationally defined and finally, a synthesized conceptual framework, including the models and extension, is presented as a diagram.

2.1 Pedagogical Triangle

The first model that frames this study is the *pedagogical triangle*. It is used to organize the local roles and interactions that emerge from the study of hands-on interactive exhibits. The ambition of finding a way to describe the interactions that occur in educational processes is not by any means a new one. John Dewey, in 1916, described interactions as the most important part of the educational process and thinkers going as far back as Socrates have referred to educational relationships. It is not surprising then that a number of researchers have proposed models that define, in a very similar way, the interactions of the educational process. In 1988 in France, Jean Houssaye described his version of the *pedagogical triangle* (see Figure 1) and the American Michael Moore, proposed a very similar structure in 1989 (see Figure 2). Both versions of the *pedagogical triangle* includes the same three roles at its corners and set of interactions between

them. This section will present the actors and interactions in the *pedagogical triangle*, and describe how it can be used as a frame for organizing those roles and interactions in an educational process. Special attention will be paid to its application in museum and science centre settings.

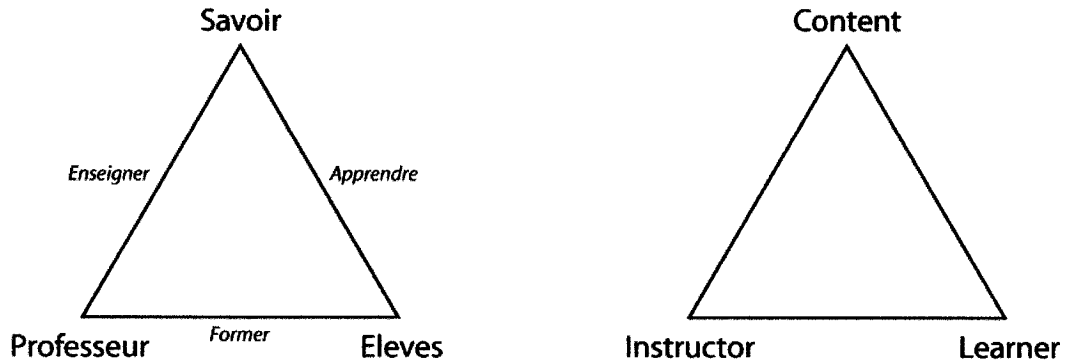


Figure 1: *Pedagogical Triangle (Houssaye, 1988)* Figure 2: *Pedagogical Triangle (Moore, 1989)*

2.1.1 Roles Within the Pedagogical Triangle

At each corner of the *pedagogical triangle* is a concept that corresponds to a role played within an educational process. These roles are broad and can be performed by individuals or objects, synchronously or asynchronously. The following section will outline the three concepts, the *Learner*, the *Teacher* and the *Content*, that relate to these roles.

First, any situation in which learning takes place requires a *learner*, or as this actor is named by Houssaye (1988), a *student*. In the case of museums and science centres, the intended recipient of learning experiences is more often identified as the *visitor*. Though the term *visitor*

encompasses a wide variety of roles for individuals, even students in school groups, they are still called *visitors*.

Second, the concept of the *teacher* must be addressed. While Houssaye (1988) refers to this role as *teacher*, Moore (1989) refers to it as *instructor*. For the purposes of this study the term *teacher* will be used, although in the case of museums and science centres the role of *teacher* can be performed by a number of different individuals or groups. When school classes visit a museum, for instance, teachers who accompany them take on the *teacher* role in the *pedagogical triangle*. When a member of the general public visits, however, guides or interpreters, who are employed by a museum to help visitors in their experience, often take on that role. A slightly more unusual group who can take on the *teacher* role is that of exhibition designers. Although not physically present, exhibition designers may also be considered as *teachers* because of the way their choices impact the learning experiences of visitors.

Third, since exhibits, the results of the work of exhibition designers, are the primary focus of this study, and exhibits fall within the *pedagogical triangle* concept of *Content*, then *Content* must also be expounded upon. This concept, designated as *content* by Moore (1989), is described as 'savoir' by Houssaye (1988). The French word 'savoir' which Houssaye uses, is related to both the English words 'knowledge', referring to the product, and 'knowing', referring to the process. In the present study, the word *content* is chosen because, in the case of museums, it is reflected in the objects (exhibits) that make up exhibitions.

2.1.2 Interactions Within the Pedagogical Triangle

Between the roles of the *pedagogical triangle* are the interactions that link them together: the *Learner – Content* interaction, the *Learner – Teacher* interaction and the *Teacher – Content* interaction. The study of these interactions reveals the dynamic nature of a learning situation. Therefore, the following section outlines these interactions particularly within the museum context.

When discussing the interaction between *learners* and *content*, Moore describes it as “...the process of intellectually interacting with *content* that results in changes in the learner's understanding, the learner's perspective, or the cognitive structures of the learner's mind” (Moore, 1989, pp. 2). Books, for instance, in the form of didactic texts are considered the earliest form of distance education, typifying one-way content interaction in learning systems (Moore, 1989). Hands-on interactive exhibits, in contrast to books, further develop the concept of *content* interaction, giving the *learner* the opportunity to actively participate. Museum and science centre exhibits are complex learning systems that include multiple types of interactions between learners and content, but still follow the basic process identified by Moore (1989).

Besides the *learner – content* interaction, the learning process depends heavily on the *learner – teacher* interaction. In traditional classroom settings, the interaction that occurs between *learners* and *teachers* is generally immediately identifiable. In museums and science centres, however, the interaction is much less obvious. Indeed, the role of *teacher* in the museum setting can be filled by a number of different actors, including guides, interpreters, teachers with school groups, and exhibition designers. The actor of most interest in this study is the exhibition designer. Moore describes the *learner – teacher* interaction as the, “...interaction between the

learner and the expert who prepared the subject material, or some other expert acting as instructor” (Moore, 1989, pp. 2). As the actor who prepares the subject material in an exhibition, the designer clearly fits within Moore's definition of the *learner – teacher* interaction. Though exhibition designers are not generally physically present in exhibitions, visitors can interact with them by proxy. Evaluation and study of visitor experiences within an exhibition is a process that is well established in many museums and science centres. This process gives visitors the opportunity to interact with designers by way of interviews, observation, and questionnaires. Input from visitors collected during evaluation then has the possibility of modifying an existing exhibition or shaping future developments. In this way, there exists the possibility for two-way interaction between designers and visitors.

In a museum or science centre context, the interaction between *teacher* and *content* occurs, for exhibition designers, during the process of developing exhibitions and programs. For guides, teachers and interpreters, this interaction occurs on the floor of the exhibition. The interaction between exhibition designers and *content* is, in essence, the development process itself. This process is generally a long one, involving the creation of exhibits designed to satisfy particular requirements set by designers and museum administrators. In any modern museum or science centre that has in its mandate the education of its visitors, one of the requirements of an exhibit is to fulfill a set of educational objectives. Since designers are not physically present on the floor of an exhibition, it is in the interaction that they have on the *content* of that exhibition that they can exert an influence to help meet those objectives.

The basic form of the *pedagogical triangle* is one that describes the local roles and interactions present in educational situations. This model has been extended, by Anderson and

Garrison (1998), in ways that are of particular relevance to this study. This extension will be discussed in the following section.

2.2 Extension of the Pedagogical Triangle

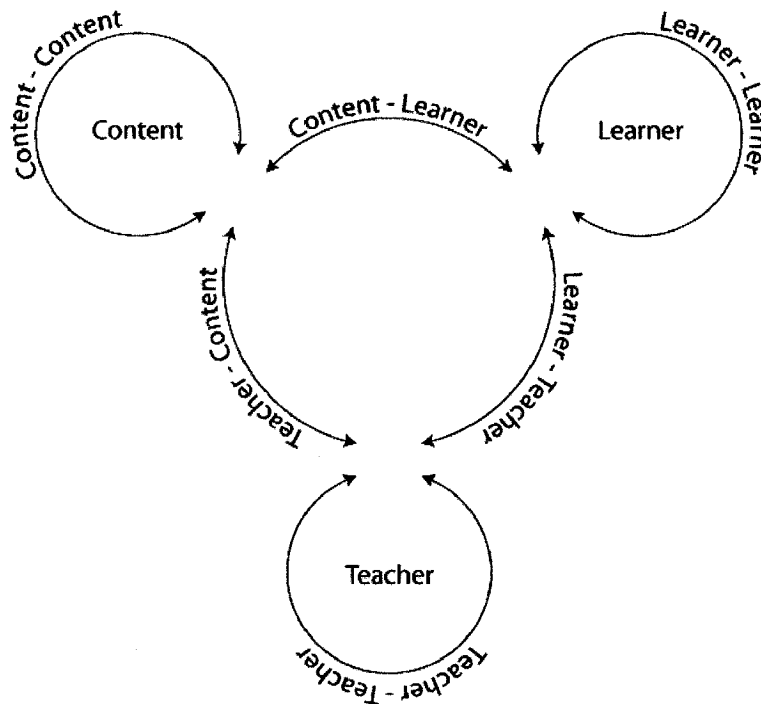


Figure 3: Pedagogical Triangle (Anderson and Garrison, 1998)

Working to extend Moore's (1989) version of the *pedagogical triangle*, Anderson and Garrison (1998) created a version of the triangle that includes a set of interactions not previously represented (see Figure 3, above). The interactions added are: *student – student*, *teacher – teacher*, and *content – content* (Anderson, 2004). Since both Moore (1989) and Anderson and

Garrison (1998) were working from the perspective of distance education, the addition of new interaction modes is partly attributed to new technological dimensions (Anderson, 2004). A connection can be seen between the addition of these new interactions and an increased availability of collaborative distance education technologies, like digital message boards, in particular. While Anderson and Garrison's additions to the pedagogical triangle were intended to make the model more applicable to modern distance education, it is also applicable to museum and science centre contexts.

Museum exhibitions are forms of educational technology and resemble distance education technologies by also acting in proxy for their creators. The largely one-way interaction between exhibition designers and museum visitors, through the *content* the designers have created, is much like the relationship between the creators of one-way distance education materials and the students who use them. Technologies similar to those that have helped to bring new modes of interaction to the forefront in distance education have also had an effect on museum and science centre exhibitions. For instance, designers have at their disposal technologies that make *content – content* interactions possible. The recognition of expanded possibilities for interactions makes Anderson and Garrison's (1998) extension to the *pedagogical triangle* important not only for distance education but also for museum and science centre exhibitions. Therefore, this study uses the *pedagogical triangle*, as extended by Anderson and Garrison (1998), to organize the local interactions that emerge in the study of hands-on interactive exhibits. The broader global context of those interactions are then examined using Falk and Dierking's (2000) *Contextual Model of Learning*. That model is described in the following section.

2.3 Contextual Model of Learning

As a global conceptual viewpoint, the *Contextual Model of Learning* (see Figure 4, below) proposed by Falk and Dierking (2000), is a solid basis for the analysis of learning within museums and science centres. This model is used in this study to frame the broad global context of the roles and interactions of the *pedagogical triangle*.

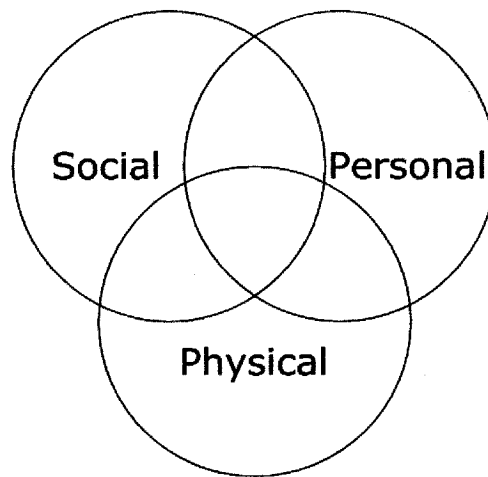


Figure 4: The Contextual Model of Learning (Falk and Dierking, 2000)

Through the *Contextual Model of Learning*, the experience of learning in museums is framed within interaction of the *personal*, *physical*, and *social* contexts. These contexts invite individuals to conduct a dialogue between themselves and their physical and sociocultural environments (Falk and Storksdieck, 2005). Each of these three contexts will be examined in this section.

The *personal context* is a representation of an individual's lived experience when approaching a learning opportunity (Falk and Dierking, 1992). It recognizes the prior knowledge and understanding that learners bring with them, and the subsequent effects on their learning

experiences (Falk and Storksdieck, 2005). Five major factors have been identified as important within the personal context: visit motivation and expectations, prior knowledge, prior experiences, prior interests, choice, and control (Falk and Storksdieck, 2005).

The *social context* represents the role of culture and society in informal learning experiences (Falk and Storksdieck, 2005). This context includes those individuals with whom a visitor attends an exhibition and those encountered during the experience (Falk and Dierking, 1992). Particularly in the case of museums, the *social context* also serves to recognize the particular cultural milieu of an institution within society and the impact that factor has on learners' experiences. Two particular types of social mediation have been identified as important: mediation within the social group with which a visitor attends and mediation by others outside that immediate social group (Falk and Storksdieck, 2005).

Learning takes place within an environment. The *physical context* encompasses this environment by including properties ranging from architecture and lighting to text and objects (Falk and Storksdieck, 2005). This context acknowledges that within informal learning settings, such as museums and science centres, the learners' experience is generally voluntary and non-sequential and thus often highly reactive to the physical setting (Falk and Dierking, 2000). Five major factors have been identified as important within the physical context: advance organizers, orientation to the physical space, architecture and large-scale environment, design and exposure to exhibits and programs, and subsequent reinforcing events and experiences outside the museum (Falk and Storksdieck, 2005). It is this *physical context* and, specifically, the factor of the design of exhibits that is the focus of this study.

While this project solely investigates the *physical context* of hands-on interactive exhibits in relation to visitor learning, the use of Falk and Dierking's model in examining the complexity of a museum visitor's experiences recognizes that the *physical context* is only one part of that experience. Using the model as part of the present conceptual framework situates the *physical context* within the broader global visitor learning experience. In the next section, concepts relevant to this conceptual framework will be operationally defined. This section will be followed by a synthesized diagram representing the complete framework.

2.4 Operational Definitions

A number of relevant concepts must be operationalized and defined for the purposes of this study. In this section, these concepts: Interactive and Hands-on; Exhibition and Exhibit; and finally, Pedagogical Perspective will be discussed.

The terms *hands-on* and *interactive* are often used interchangeably when referring to an entire class of museum exhibits that can be touched or manipulated. A number of terms including *minds-on*, *participatory*, and *immersive*, are also used to describe similar museum experiences. Arguments can be made for these terms along with *hands-on* and *interactive*, referring to distinct levels within the greater term of *interactivity* (Adams and Moussouri, 2002). The term *interactive* for instance, as a term that emphasizes the visitor's part in interaction, can be applied to most exhibits within the general class, but is used in many cases to solely describe computer-based experiences (Adams and Moussouri, 2002). The Oxford Dictionary defines *interactive* as, "allowing a two-way flow of information between it and a user, responding to the user's input" (Pearsall and Trumble, 1996, pp. 732); and *hands-on* as, "involving or offering active

participation rather than theory: direct, practical” (Pearsall and Trumble, 1996, pp. 638). For the purposes of this study both the terms *hands-on* and *interactive* will be used in their broader sense, referring to that class of museum and science centre exhibits that can be touched or manipulated.

When a museum or science centre creates a discrete presentation for visitors, it is creating what is generally referred to as an *exhibition*. Exhibitions themselves are then made up of many smaller components that present discrete concepts or themes to visitors within the overall theme of the *exhibition*. These smaller components that make up the greater whole of an *exhibition* are generally referred to as *exhibits* (Falk and Dierking, 1992). The Oxford Dictionary defines *exhibition* as, “a display (especially public) of works of art, industrial products, etc.”; and *exhibit* as, “a thing or collection of things forming part or all of an exhibition” (Pearsall and Trumble, 1996, pp. 490). For the purposes of this study, *exhibition* refers to the massed public display of *exhibits*, organised around a central theme or set of themes. *Exhibit* refers to an element of a larger *exhibition* that displays a thing or number of things.

The term *pedagogical perspective* can engender a number of connotations and definitions. For this study, the term is taken to closely follow the Oxford Dictionary definition of *pedagogy*, “the science of teaching” (Pearsall and Trumble, 1996, pp. 1070).

2.5 Synthesized Conceptual Framework

While the *pedagogical triangle* situates the local roles and interactions that emerge from the study of hands-on interactive exhibits, Falk and Dierking's (2000) *Contextual Model of*

Learning provides a frame that situates those roles and interactions in a broader context.

Synthesized as a framework for this study, the two models create a structure that situates the examination of the *physical context* of hands-on interactive exhibits at both a local and at a broader global level. This synthesized conceptual framework is represented in Figure 5, below.

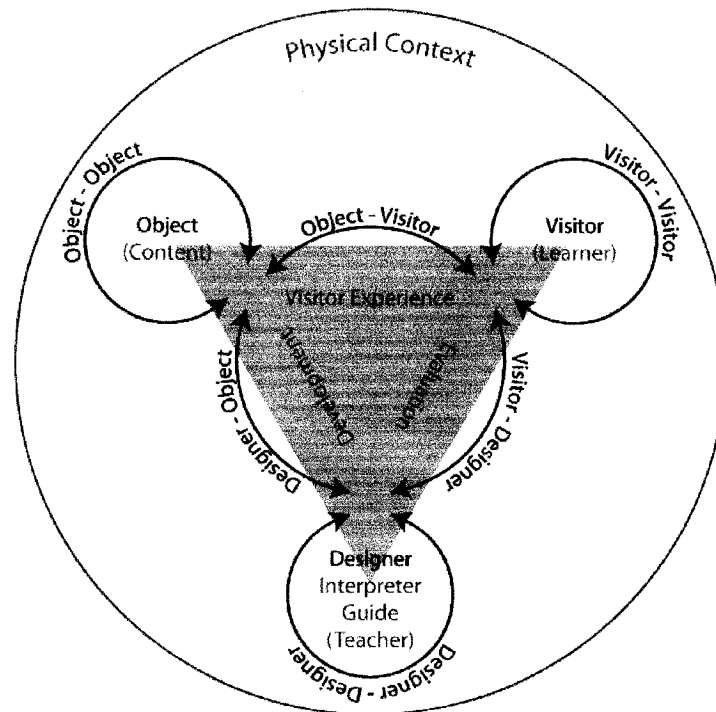


Figure 5: Synthesized Conceptual Framework

2.6 Conclusion

In this chapter, the conceptual framework for a study of hands-on interactive exhibits from a *pedagogical perspective* has been developed. First, this framework consists of an extended version of the *pedagogical triangle* (Anderson and Garrison, 1998), that was examined via the roles it encompasses: *teacher* (designer), *learner* (visitor) and *content* (object), as well as the interactions between them. For the purposes of this study, the *pedagogical triangle* is used to organize the local roles and interactions that emerge from the study of hands-on interactive exhibits. Second, the conceptual framework includes Falk and Dierking's (2000) *Contextual Model of Learning*, which was addressed via its three overlapping contexts: *personal*, *social* and *physical*. Although the *physical context* is the context of particular interest to this study, the overall model is referenced so that this context may be situated within the broader global context of learning in museums and science centres. After the examination of the two models a number of relevant terms were operationally defined; and finally, a synthesized conceptual framework was then presented as a diagram. In the next chapter, the methodology employed in this study will be specified.

3. Methodology

Building on the background and conceptual framework already established, this chapter will address the method taken to examine the categories and concepts of the *physical context* of hands-on interactive exhibits. For this examination, a descriptive process was undertaken of the exhibits within three exhibitions at the *Montreal Science Centre*. This chapter will first discuss the setting for the study, namely the *Montreal Science Centre* and the three exhibitions chosen: *Eureka!*, *X-Treme Rotation*, and *Technocity*. Then, the process of collection and analysis of data will be expounded upon, and finally, issues of validity and reliability will be addressed.

3.1 Setting

The hands-on interactive exhibits that were examined during the course of this study were housed within two major permanent exhibitions and one temporary exhibition at the *Montreal Science Centre*. Each of these exhibitions, *Eureka!*, *X-Treme Rotation*, and *Technocity* encompasses a broad variety of hands-on interactive exhibits. These three exhibitions were chosen because they represent a large diversity of themes, content, and technical approaches. In this section, the setting of the overall science centre along with the three exhibitions examined are described.

3.1.1 Montreal Science Centre

The *Montreal Science Centre* is a relatively large regional science centre with several exhibition spaces available. In format, the centre follows the tradition of science centres started in 1969 with the opening of the *Exploratorium* in San Francisco and the *Ontario Science Centre* in Toronto and provides a wealth of hands-on interactive experiences organised around science and technology themes. On the *Profile* page of the centre's website, the staff at the *Montreal Science Centre* have defined a mission statement, “The mission of the Montreal Science Centre is to help visitors of all ages acquire an understanding of science and technology for use in building their future” (Montreal Science Centre, 2006, see Appendix A). Thus, the centre aims to both foster understanding and positively affect visitors' lives. The centre is funded by the Canadian federal government as part of the *Old Port of Montreal* crown corporation. On average, six million people visit the port each year and participate in a variety of cultural and recreational activities. The centre itself opened in 2000 under the name *iSci* and was renamed *Montreal Science Centre* in 2002 (Ibid).



Figure 6: Outside Montreal Science centre

Visitors to *Montreal Science Centre* (see Figure 6, above) have been exposed to a variety of exhibitions and activities since its opening, including an *IMAX* theatre, an interactive film experience, three permanent exhibitions, and at least one temporary exhibition. In the winter of 2006, when the present study was conducted, the centre showcased three permanent exhibitions, *Eureka!*, *Technocity*, and *Dynamo's Lair*; and a temporary one, *X-Treme Rotation*. The location and relative size of these exhibitions can be seen below in the overall floor plan of the centre represented in Figure 7. As a large science centre, *Montreal Science Centre* provides a broad variety of hands-on interactive exhibits. It is also a place where the staff is open and welcoming to researchers. This support is one of the major factors that make the *Montreal Science Centre* a

suitable setting for this research (see Appendix B for a letter of permission from staff at the *Montreal Science Centre*). The three exhibitions chosen for study, *Eureka!*, *Technocity*, and *X-Treme Rotation*, encompass a particularly wide variety of design techniques and content areas. Each of these three exhibitions will be discussed in the paragraphs that follow.

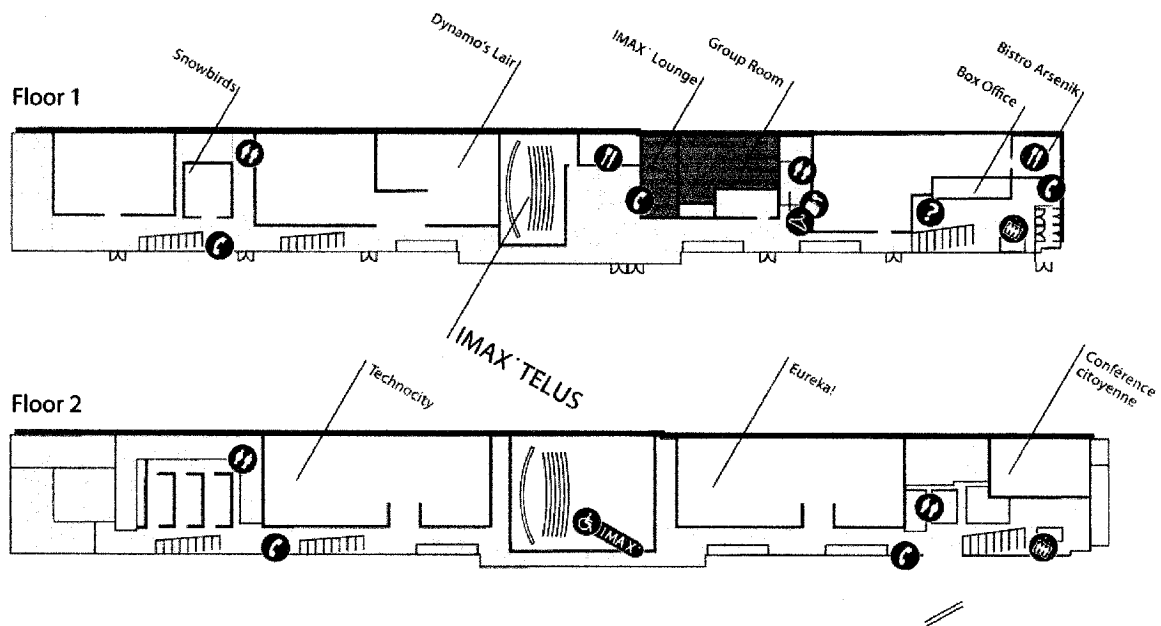


Figure 7: Overall Floor Plan (Montreal Science centre, 2006)

3.1.2 *Eureka!*

Eureka! is a permanent exhibition which focuses on the theme of the sciences as they relate to everyday life (Ibid). It opened in 2002 when the centre was redeveloped and renamed *Montreal Science Centre*. The exhibition contains 41 individual exhibits organised into five themes, making it the largest exhibition at the *Centre*. Those themes are: *Health*, with content on

food and the health sciences; *Matter*, with content on the physical properties of materials; *Habitat*, with content on adaptation to the environment; *Waves*, with content on sound and light waves; and *Forces*, with content on unusual physical phenomena (see Appendix A for descriptions from the *Montreal Science Centre* website). Much of the floor space in *Eureka!* is dedicated to an amphitheater presenting live demonstrations (see Appendix C for a floor plan of *Eureka!*).

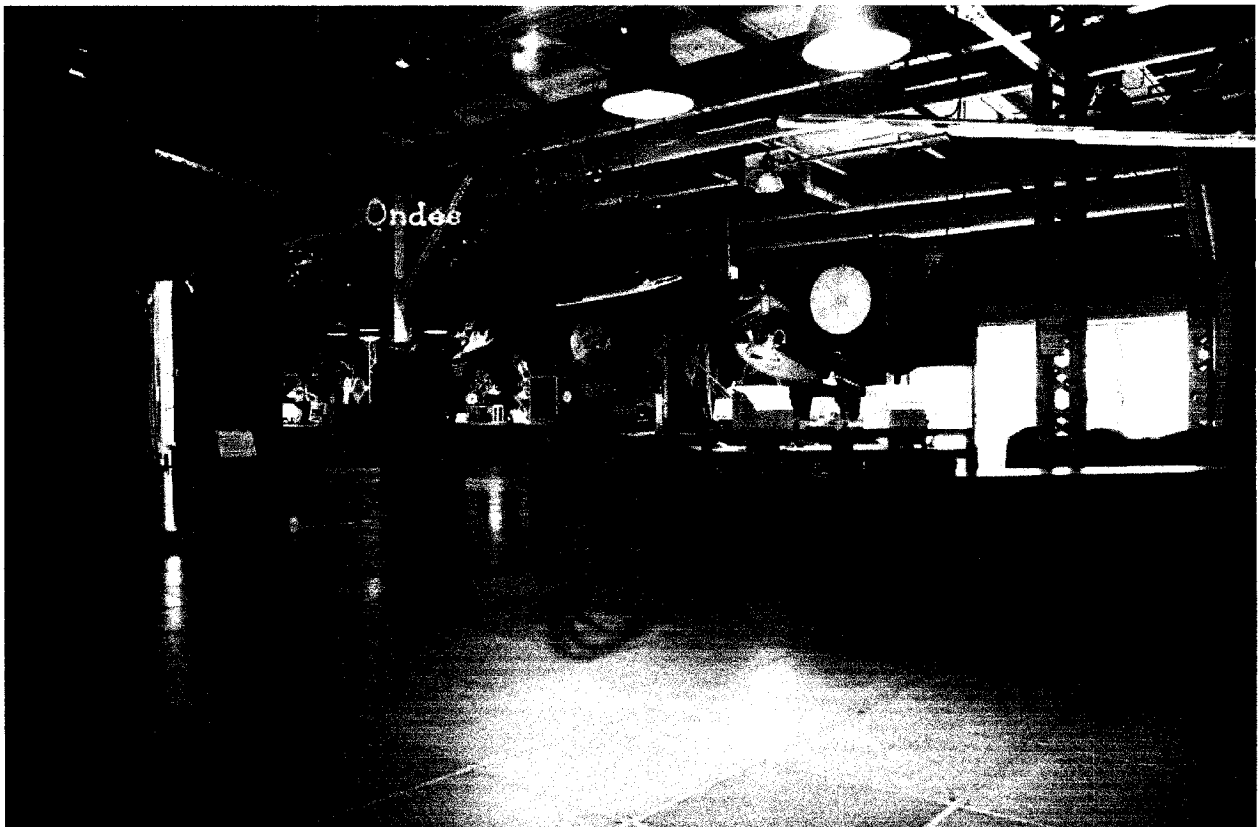


Figure 8: Eureka! with windows to outside

Physically, *Eureka!* has been constructed around the existing structure of the building. By leaving much of the building's steelwork structure exposed, the visual language of a raw industrial scene is created. As can be seen in Figure 8, there is a large window to the outside on

one wall of the exhibition that makes visible a group of old ships at dock. This provides an interesting 'real world' context for the exhibition and provides natural light. The opposite long wall of the exhibition (see Figure 9, below), is constructed of glass artifact cases. This use of artifacts as a semi-translucent screen lets natural light into the exhibition and allows visitors to glimpse into the exhibition from the main corridor outside. Though the presence of natural light is found in both *Eureka!* and *Technocity*, it was not present in the next exhibition to be discussed: *X-Treme Rotation*. As will be discussed, limiting natural light creates a distinctly different look and feel to an exhibition space and affects choices such as materials and signage used in individual exhibits.



Figure 9: Glass wall with artifacts

3.1.3 *X-Treme Rotation*

The control of natural light by way of relatively minimal ambient lighting and a reliance on directed light sources created a design language of contrasting bright areas and shadows in *X-Treme Rotation* (see Figure 10). This is a distinctly different look and feel to either *Eureka!* or *Technocity*, both of which make use of ambient natural light. Exhibits within *X-Treme Rotation* reflected this design language with the use of minimal physical structures punctuated by attention-grabbing graphic panels, screens, and objects.



Figure 10: X-Treme Rotation

Of the three exhibitions, *X-Treme Rotation* was the only temporary exhibition and was on display in 2005 and early 2006. The exhibition occupied a 500 square meter space dedicated to

temporary exhibitions on the ground floor of the centre (see Appendix C for a floor plan of *X-Treme Rotation*). Five themes divided the exhibition: *Robots... manifold rotation*, an interactive art installation; *Objects... high performance rotation*, about wheels, gears, screws, levers, and gyroscopes; *The Body... all-round rotation*, about rotation within the body; *The Universe... infinite rotation*, about inertia, centripetal force and centrifugal force; and *Creation... rotation galore*, where visitors were encouraged to engage with creative activities that allowed them to experience rotation (see Appendix A for descriptions from the *Montreal Science Centre* website). These themes were explored through a variety of interactive hands-on and multimedia exhibits. Unlike the other exhibitions examined in this study, not all the exhibits within *X-Treme Rotation* were interactive or hands-on. *The Universe... infinite rotation* theme, for instance, had relatively few interactive or hands-on exhibits but included a large dynamic video representation of the solar system upon multiple screens. Other exhibits pushed the boundaries of what can be considered interactive. The theme, *The Body... all-round rotation*, for example, encompassed an exhibit with a life-size video wall that invited visitors to stand in front and mirror a character's movements. Though visitors were encouraged to become actively engaged in the activity, they did not have any control over the exhibit itself, and the exhibit did not respond to their actions. This does not fulfill the criteria for many definitions of interactive that require responsive actions by both parts of an interaction. By testing the definition of interactive, this type of exhibit provided a particularly interesting case for this study.

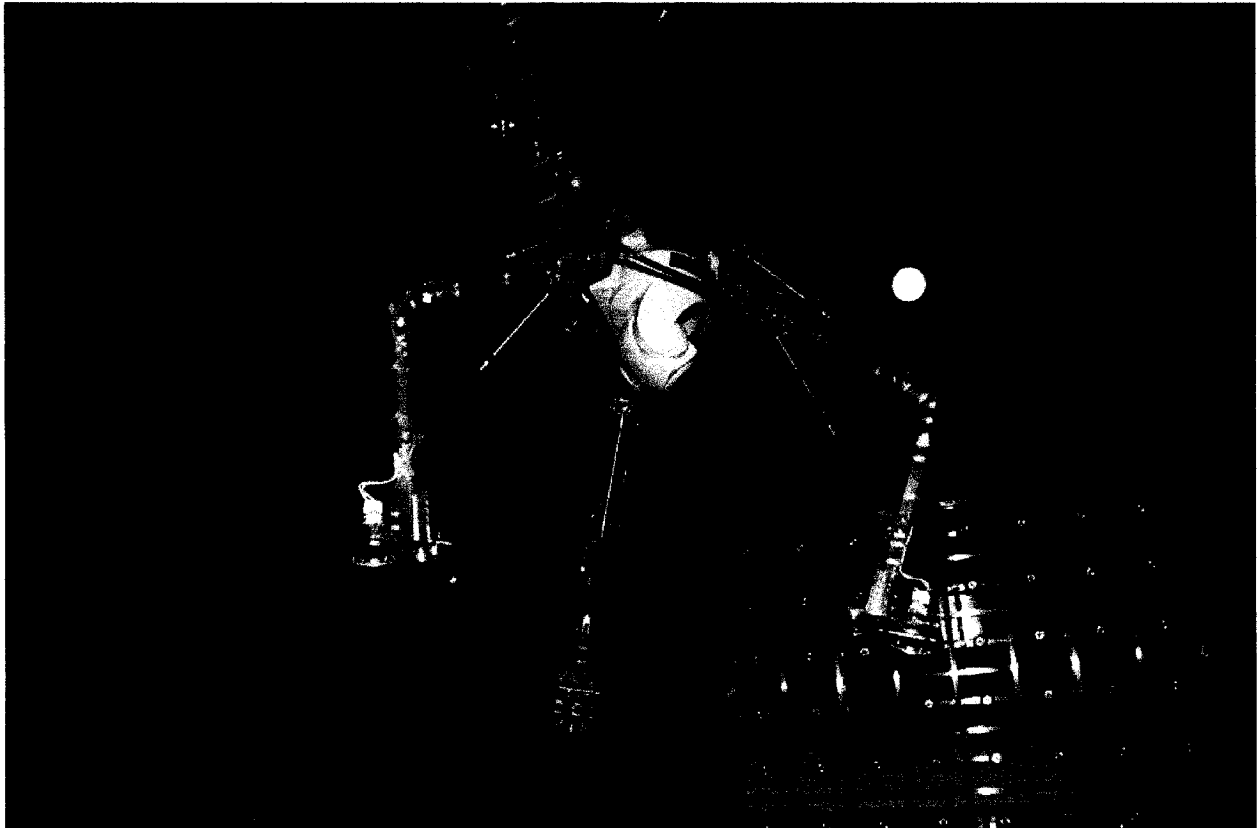


Figure 11: Rotoscopic Machines by Bill Vorn

Several of the themes explored comprised activities that were aesthetic in nature like dance or drawing, for example. This was distinct from the other exhibitions examined and was one of the most obvious differentiating features of *X-Treme Rotation*. The *Robots... manifold rotation* theme, for example, was composed entirely of *Rotoscopic Machines* (see Figure 11, above), a mechanical robotic art installation by artist Bill Vorn who was prominently featured in interpretive graphics and text panels.

Though smaller than the other two exhibitions examined, *X-Treme Rotation* provided a wealth of information. The exhibition's temporary nature also provided insight into the scope of interactive and hands-on exhibits when an exhibition is designed for only months of use and not

decades as is typical with permanent exhibitions. It also provided valuable insight into the use of aesthetics-focused activities in exhibits, a feature distinct from the other exhibitions.

3.1.4 *Technocity*

A large permanent exhibition, *Technocity* has 36 hands-on or interactive activities, and is similar in both scale and treatment to *Eureka!* (see Appendix C for a floor plan of *Technocity*). As the name suggests, *Technocity* is focused on the theme of technology and its applications in industry. Within that theme there are four major groupings displayed: *Computers and robotics*, about computer languages and robot programming; *Design and development*, about the creation of new products; *Communication and information*, about binary and digital communication; and *Energy and resources*, about resource exploitation and management (see Appendix A for descriptions from the *Montreal Science Centre* website). As is the case with both *Eureka!* and *X-Treme Rotation*, each thematic grouping is well defined with large signage and physical groupings. More so, however, than the other exhibitions, *Technocity* displays a strong cohesive visual style. The presence of a large simulated factory production line that runs across thematic groupings (see Figure 12, below), provides a literal connecting thread. This production line consists of conveyor belts on which a steady stream of cube shaped boxes with simple graphics of different products appear. The conveyor emerges and disappears throughout the length of the exhibition and visually ties the thematic groupings together.



Figure 12: Technocity with simulated production line

In *Eureka!*, a large amphitheater, serves as a place for demonstrations and live activities. A similar role is performed in part within *Technocity* by a digital radio studio, visible to visitors through a glass wall. As a form of live demonstration, visitors can look in on people working in the studio while listening to the radio programs being created. Adjacent to this radio studio are large windows to the outside. These windows are particularly relevant in *Technocity* due to the connection between the exhibition's themes of technology and industry, and the industrial scene outside the museum. Through the windows, a river port can be seen with both historic and functioning modern sections. The scene makes a fitting backdrop to *Technocity* and connects several of the themes explored within the exhibition to the world outside.

Each of the three exhibitions provides a broad variety of interactive and hands-on exhibits. This breadth was further augmented by the different interpretive approaches and content found within each exhibit. In particular, the temporary nature of *X-Treme Rotation* provided important differences in the design of individual exhibits from those found in either of the permanent exhibitions. In addition, the centre has an administration and exhibition-planning staff that is open and welcoming to research. This provided invaluable resources and the opportunity for dialogue throughout the course of the project. These factors served to make *Montreal Science Centre* an appropriate setting for the study of hands-on interactive exhibits.

3.2 Data Collection and Pre-Analysis

In order to examine the hands-on interactive exhibits found within the three exhibitions at the *Montreal Science Centre*, a process of descriptive and document analysis techniques was employed. The use of document analysis techniques follows the logic that as artefacts of material culture, hands-on interactive exhibits can be treated like documents for the purposes of analysis (Hodder, 1998). Examination began with the collection of detailed descriptions and photographs of the exhibits and their context. This collection took place in a sequential fashion where, as suggested by Creswell (1994), the transition between collection and analysis of data was blurred in nature, with some analysis overlapping with the collection phase of the project. This overlapping nature of the phases aided in the development of categories and formatting of the information into a relevant picture (Creswell, 1994).

The procedure for the collection of data in this study will be described in the following section. First, the preparation undertaken before on-site visits at the science centre will be

explained. Then, immersion in an exhibition, individual exhibit observation, description, and photography will be discussed; and finally, an on and off-site reflection process will be presented.

An initial visit to *Montreal Science centre* was performed during the preliminary stages of this research project. This visit allowed the researcher to become familiar with the *centre* and to determine its suitability as a site for detailed study. Since the *centre* had a variety of exhibitions that encompassed a large breadth of different exhibition techniques and content areas, it was determined to be an appropriate location. During this initial visit a number of promotional materials made available by the *centre* were collected. These materials along with the *centre's* website were then read to gain an understanding of how the staff at the *centre* situate it and its exhibitions for the visiting public.

Using the promotional material and preliminary visit experience as a guide, the three exhibitions to be studied were chosen: *Eureka!*, *X-Treme Rotation*, and *Technocity*. Floor plans for each of the three exhibitions were requested from the *centre*. These plans were then examined and the locations of major exhibition components noted. Thematic groupings of exhibits and a coding scheme assigned by the *centre* to each exhibit were present on the floor plans and thus could also be examined and noted. These groupings and codes were then used to create the structure for a database. The database was used on site to collect descriptions and photographs directly into a structure that related back to the floor plans.

Upon first entry into one of the three exhibitions, a thorough exploration took place. General descriptions and photographs were collected in order to capture that initial experience and major features of the exhibition were checked against the floor plan. The identification of

major features allowed a basic check for accuracy of the floor plans. Once this orientation exercise was complete, the position of each individual exhibit was verified against the floor plan. Since the floor plans provided by the *centre* were produced for the initial installation of the exhibitions, a number of exhibits had been moved, removed, or added. Care was taken to note all of these cases and to modify the floor plans to bring them up to date.

Using the updated floor plans and the database prepared earlier, each individual exhibit was approached and the context of its position within the overall exhibition, as well as its thematic grouping, noted and photographed. Each exhibit was then examined fully, with all possible avenues of activity explored. In the case, of digital exhibits with multiple choices and paths, for instance, each choice and path was taken. In each case equally focused attention was paid to fully experiencing the exhibit. Though each exhibit needed to be described and photographed in detail, during this initial time with an exhibit a deliberate choice to have an experience unencumbered with writing and photography was made.

Along with each individual exhibit, the overall exhibition and each thematic grouping was described. A list of features to note at each exhibit was compiled and used as a guide during the writing of the descriptions: Physical setup; Text, graphics, and artifacts; Manipulatable and non-manipulatable elements; Process (use cycle); Apparent outcomes / goals. While in reality the descriptions went far beyond this initial list of features, it helped to set the descriptive process. Care was taken throughout the process to describe completely each exhibit and, as new features emerged, exhibits already examined were revisited.

Along with the written descriptions, multiple levels of photographs were taken of each exhibition, thematic grouping, and individual exhibit. In the case of an individual exhibit, the

process of photography followed from the features noted directly before in the written description as well as from a general list of features to focus on which was created before the on-site visit. This list of features to photograph was, as with the general list of features for the written descriptions mentioned earlier, a starting point which was adapted as needed: Overall exhibit from multiple angles; Manipulatable and changing elements; Activities completed and uncompleted; Screens from each major section of digital exhibits; and Text / graphic panels and artifacts. Throughout the process of examining an exhibition, care was taken to return to previously photographed exhibits and capture any applicable features that emerged from other exhibits.

After descriptions and photographs had been taken for all the exhibits in a particular thematic grouping, those exhibits were then examined in the context of that grouping. Changes and additions, like those features to be addressed in exhibits examined earlier, were made when necessary to both the written descriptions and photographs. Similarly, once all the exhibits within an exhibition had been described and photographed, time was taken on-site to reflect on the entire experience and make additions where necessary.

In the days directly following the on-site investigation of each exhibition, the descriptions and photographs that had been collected were reviewed and refined. These refinements included the correction of factual and typographic errors, and adding details in the descriptions. As part of this reflection process, the complete set of descriptions and photographs was then re-read and examined to ensure complete familiarity with the content. With a detailed set of written descriptions and photographs, and strong familiarity with all the content contained within, analysis could then begin.

3.3 Analysis

In this section, the analysis that took place will be described. First, concepts and categories that emerged from the descriptions and photographs were captured in a process of inductive analysis. Second, the *pedagogical triangle* introduced in the conceptual framework chapter, will be used to frame those concepts and categories.

The first stage of analysis that was performed was the identification of emerging concepts from the written descriptions and photographs. Examining one exhibition at a time, a list of concepts was compiled. The set of criteria used during the collection process was used as a guide in identifying concepts: physical setup; text, graphics, and artifacts; manipulatable and non-manipulatable elements; process (use cycle); apparent outcomes / goals; manipulatable and changing elements; activities completed and uncompleted; screens from each major section of digital exhibits; and text / graphic panels and artifacts. Far from being prescriptive, the list of features was instead used as it had been in the collection process: as a starting point from which elements could be added, modified, or abandoned. The list of concepts that emerged in each exhibition was compared across the three exhibitions and repeated concepts were eliminated. This process resulted in a master list of concepts from all three exhibitions that constituted a set of categories (see Appendix D for examples of this process). Particular attention was paid to concepts that had either a complementary or opposing relationship. As categories emerged, they were constantly checked against exhibit descriptions and photographs. This process continued with the formation of a structure of higher level and sub level categories that could be consistently checked against exhibit descriptions and photographs from all three exhibitions.

With a structure of categories and concepts identified, the *pedagogical triangle* was used to frame the emergent concepts and categories. Those that were harder to classify within that frame, were re-evaluated by examining the exhibit features that supported them. Those categories and concepts were then re-organized with the *pedagogical triangle* in mind, but taking care to ensure that they could still be supported by the exhibit descriptions and photographs that they were drawn from. This final step completed a cohesive structure of the emergent concepts was established.

3.4 *Validity and Reliability*

The following section will describe issues of validity and reliability. First, a guiding principle of validity will be discussed, and second, a process of external validation will be outlined. Throughout the process of this study, Erickson's (1986) concept for the validity and reliability of interpretive studies was followed as a guiding principle. Erickson suggests that the primary measure of validity in any interpretive research should be, from the actor's point of view, the attention given to the immediate, local meanings of any action. Since in the case of the study discussed here, the actors are objects and not individuals, Erickson's premise cannot be taken strictly at face value. Using Hodder's (1998) definition, hands-on interactive exhibits are, however, artifacts of material culture. As such, they were created by what Erickson describes as *actors* and can be seen to be acting in proxy for those individuals. With this in mind, a great deal of attention was given to the immediate and local meanings of the characteristics of the hands-on interactive exhibits examined.

To ensure the validity and reliability of the analysis and categorization of the exhibits in the three exhibitions, as well as the overall typology, a verification process was undertaken. As suggested by Strauss and Corbin (1990), additional knowledgeable individuals apart from the primary researcher were consulted. Three senior members of exhibition development teams at different museums (*The Canadian Museum of Nature*; *The Canada Science and Technology Museum*; and *The Montreal Science centre*) were asked to review the data collected, its analysis, and the generated findings. Their comments and suggestions, captured during individual interviews, were then weighed by the primary researcher against the written descriptions, photographs, and literature to make changes to terminology and concepts where necessary.

3.5 Conclusion

This chapter has described the context, procedure, analysis, and validation of this study. First, the context of the three exhibitions studied at the *Montreal Science centre* was described. Second, the procedure used in the collection of descriptions and photographs of the hands-on interactive exhibits found within the three exhibitions was addressed. Third, the analysis, leading to a structure, of the emergent concepts and categories from those descriptions and photographs was outlined; and finally, issues of validity and reliability were discussed. The findings that emerged as a result of this process will be described in the next chapter.

4. Findings

The purpose of this study is to identify and organize the categories and concepts that emerge from examining the *physical context* of hands-on interactive exhibits from a *pedagogical perspective* in three exhibitions at the *Montreal Science centre*. As explained in the conceptual framework chapter, the *physical context*, in Falk and Dierking's *Contextual Model of Learning* (2000) serves as a lens through which to focus on one of the elements that make up museum learning experiences, while the model of the *pedagogical triangle* (Anderson and Garrison, 1998) is used to examine what is identified through that lens. An analysis process, specified in the methodology chapter, was undertaken with two distinct phases. The findings of the first phase, where the exhibits were examined through the lens of the *physical context*, were then related to the *pedagogical triangle* in the second phase. Findings from that process will be presented in this chapter in relation to three specific concepts of the *pedagogical triangle*. First, those categories and concepts that associate with the *Object* will be examined. Second, those that refer to the *Visitor* will be specified; and third, the categories and concepts that pertain to the interaction between the *Object* and *Visitor* will be identified. Finally, a synthesized schematic diagram of all the categories and concepts will be presented to summarize the complete findings.

4.1 Content Categories

In museum settings, the *Content* concept of the *pedagogical triangle* concerns the exhibit itself as an object. The categories related to this concept are those that are manifested in the *physical context* of an exhibit at all times, regardless of visitor interaction. These categories are:

Content Delivery Mode, the technological device used to present content to visitors; *Content Representation*, the relationship between an exhibit's subject and its presentation; *Physical Access to Interface*, the possibility for visitors to approach an exhibit's interface from multiple sides or use that interface with others; *Physical Mechanics of Exhibit*, the underlying technology type that allows an exhibit to function; and *Physical Interface of Exhibit*, the technical nature of those elements of an exhibit that can be manipulated by visitors (see Figure 13, below). Each of these emergent categories is manifested in an exhibit at all times, whether interaction with a visitor is taking place or not. They associate directly with the exhibit as object and therefore with the *Content* concept of the *pedagogical triangle*. They will be addressed in detail in the sections that follow.

<p>1. Object (Content) Categories</p> <p>1.1 Content Delivery Mode(s): (a) Audio (b) Tactile (c) Olfactory (d) Moving Image(s) (e) Text (f) Still Image(s)</p> <p>1.2 Content Representation(s): (a) Demonstration (b) Analogy</p> <p>1.3 Physical Access to Interface(s): (a) Constrained (b) Open: Interface(s) can be approached from multiple sides (c) Open: Interface(s) can be shared by multiple users</p> <p>1.4 Physical Mechanics of Exhibit: (a) Static (b) Dynamic: Mechanical (c) Dynamic: Analogue electronic (d) Dynamic: Digital</p> <p>1.5 Physical Interface(s) of Exhibit: (a) Soft (b) Hard: Electronic control(s) (c) Hard: Mechanical control(s) (d) Hard: Direct manipulation</p>

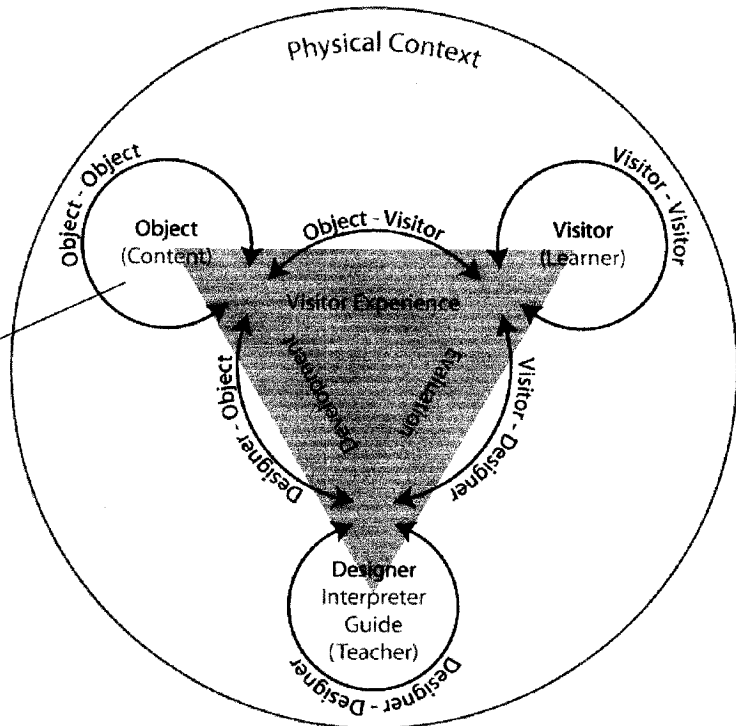


Figure 13: Content Categories

4.1.1 Content Delivery Mode(s)

This category addresses the technological concepts that can be employed for delivering content to visitors. It contains the concepts: (a) *Audio*, (b) *Tactile*, (c) *Olfactory*, (d) *Moving Image(s)*, (e) *Text*, and (f) *Still Image(s)*. In this section, each of these concepts will be defined and then illustrated using an example exhibit.

4.1.1a Audio

The concept *Audio* is defined as the use of sound, live or recorded, as a technology for delivering content. An example of an exhibit that includes *audio* as a way of delivering content is *Speaking Volumes* from *Eureka!* (see Figure 14). This exhibit allows visitors, wearing headphones, to use a mouse and monitor to explore the way waves work together to make the sound of a guitar. As sounds are made, they can be heard through the headphones.

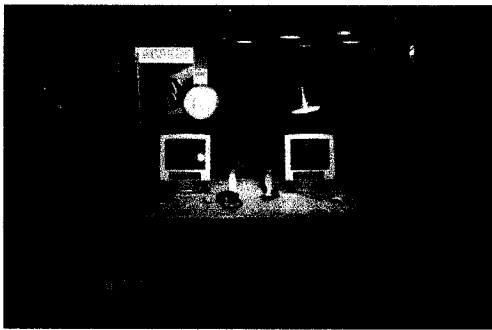


Figure 14: *Speaking Volumes*

4.1.1b Tactile

This concept represents the use of technologies that engage a visitor's sense of touch in delivering content to them. The exhibit *Building Blocks*, from *Eureka!*, is an example of such an exhibit (see Figure 15). Sixteen blocks are split between two rows, with eight different materials per row. Each material block is attached to a handle by a cable and can be lifted by visitors. The top row has blocks of varying size but identical weight, while the lower row has blocks of different weight but the same size. Visitors' sense the different weights and densities of the materials by lifting them.

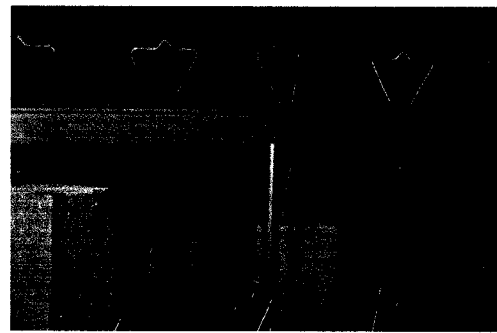


Figure 15: Building Blocks

4.1.1c Olfactory

The concept titled *Olfactory* is identified as the delivery of content through technologies that produce smell. An exhibit that delivers content using *Olfactory* technology is *Nine Little Pigs*, from *Technocity* (see Figure 16). Visitors are presented with nine plastic pig noses on a tabletop, each of which can be pushed down to produce a smell. On a panel above are images of nine different foods with buttons underneath them. Visitors are invited by text to push down a pig nose, smell it, and while holding it down press a button matching it to a food on the panel.

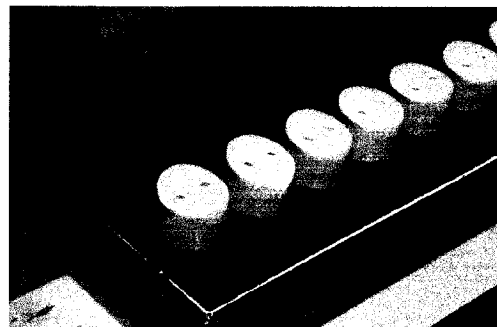


Figure 16: The Nine Little Pigs

4.1.1d Moving Image(s)

This concept refers to the use of technologies that produce moving images, including video and film, to deliver content. An example of an exhibit that demonstrates this concept is

Quiz Cuisine, from *Technocity* (see Figure 17). Visitors watch a video about a cookie factory that is presented by a comedian. At various places during the video, visitors answer questions about the content. When the questions are answered incorrectly, a noise is heard along with text that announces the wrong answer. When a question is answered correctly, the video continues with the sound of applause.

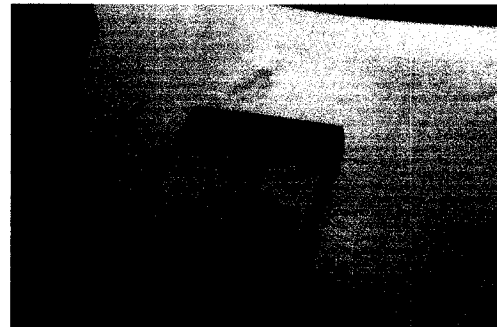
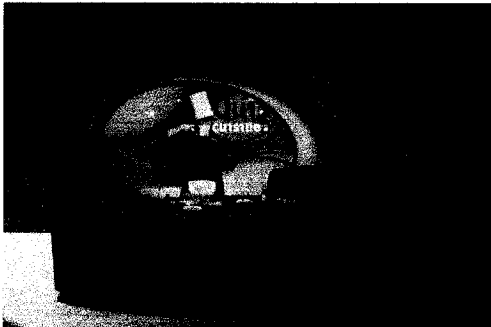


Figure 17: Quiz Cuisine

4.1.1e Text

Technologies that deliver content in written form are identified by the concept *Text*. An example of an exhibit that uses *text* to deliver content is *Health Foods: Fact or Fiction?* from *Eureka!* (see Figure 18). Visitors are presented with eleven flip-style questions on a wall. Each question raises a commonly-known idea about a certain food being good for certain medical conditions. For each of these foods and conditions, the effects are questioned. When visitors turn the panels over, they are presented with a true or false answer and some contextual information in text form.

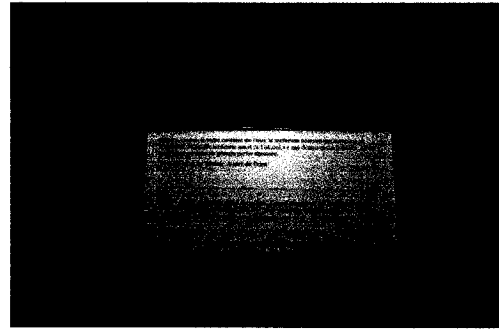
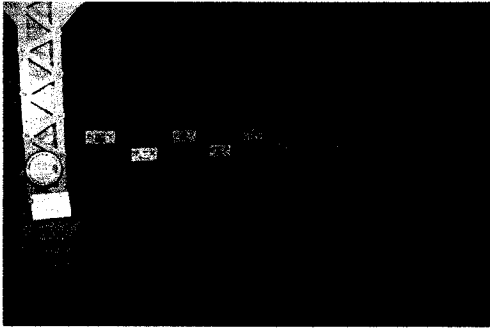


Figure 18: Health Foods, Fact or Fiction?

4.1.1f Still Image(s)

This concept is representative of the use of *Still Image* technologies, including photographs and illustrations, to deliver content. The exhibit, *To Each Job Its Lever* from *X-Treme Rotation*, is an example of an exhibit that demonstrates this concept (see Figure 19).

Visitors are invited to match three types of levers to a set of example applications. There are nine examples and three lever types. Each lever example is represented by an illustration of a common household object or tool. Each lever type is represented by a diagram of its operation.

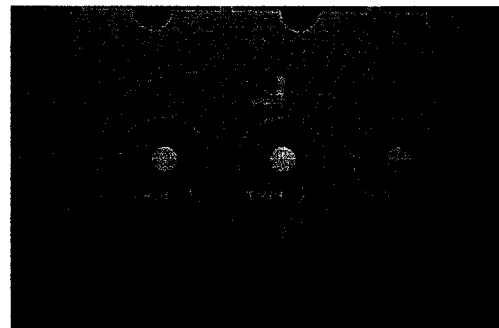
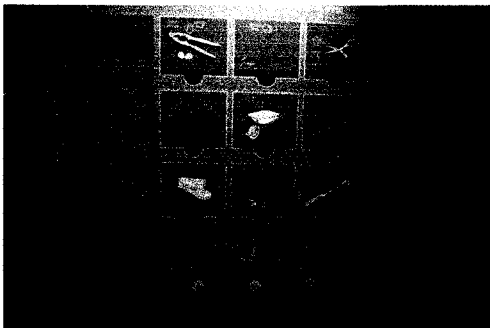


Figure 19: To Each Job Its Lever

4.1.2 Content Representation(s)

This category encompasses the relationships between an exhibit's content and its subject or theme. The concepts within it are: (a) *Demonstration* and (b) *Analogy*. Each concept will be examined in this section.

4.1.2a Demonstration

The concept identified as *Demonstration* pertains to an exhibit where the content has a direct relationship with, and is an example of its subject. An example of an exhibit that functions as a direct *demonstration* of its subject is *Who's Up for a Spin* from *X-Treme Rotation* (see Figure 20). Visitors are invited to try spinning and moving a bicycle wheel that is suspended from a post. Where the wheel attaches to the post, just above its axle, the wheel can pivot in place. Visitors experience the forces the wheel can generate by spinning it and then trying to move it on its pivot. This experience is with a direct example, or *demonstration*, of the exhibit's subject.



Figure 20: *Who's Up For a Spin*

4.1.2b Analogy

As opposed to *Demonstration*, this concept is applicable when the content of an exhibit is not a direct example of its subject. Following Gentner's (1989) definition of *Analogy*, there exists a relationship between the exhibit and its subject through a matched set of attributes that show similarity. An example of an exhibit which has an *analogous* relationship with its subject is *A Real Head Turner*, from *X-Treme Rotation* (see Figure 21). Visitors are presented with a clear acrylic disc mounted on a small round table. Inside the disc is a liquid with blue spheres suspended in it. Interpretive text invites visitors to try rotating the disk at different speeds, stopping it and then observing how the inertia of the liquid continues to move the small blue spheres. The concept of inertia is explained on a text panel in reference to the human ear and balance system. When the blue spheres move in the liquid, they behave in a similar way to the balance sensing parts of the human ear. In this way the exhibit has an *analogous* relationship with its subject.

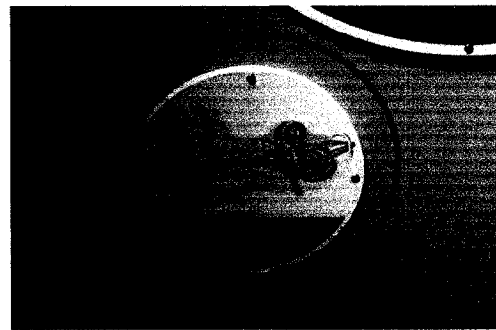


Figure 21: A Real Head Turner

4.1.3 Physical Access to Interface(s)

This category represents the physical accessibility of an exhibit's interface for visitors. It contains the concepts: (a) *Constrained* or *Open*, where the latter indicates an interface that can be approached from (b) multiple sides and/or shared by (c) multiple users. Each concept will be defined in the following section.

4.1.3a Constrained

The concept titled *Constrained* applies when the physical access of an exhibit's interface is restricted to a single visitor at a time, and to a single access point. The exhibit *My House is My Cocoon*, from *Eureka!*, is an example of an exhibit that is physically *Constrained* (see Figure 22). The exhibit is a matching activity where common house construction materials must be matched with different types of protective clothing. The exhibit can only be approached from one side and can only be used by one visitor at a time.



Figure 22: *My House Is My Cocoon*

4.1.3b Open: Interface(s) can be approached from multiple sides

This concept is apparent in exhibits that have interfaces that can be approached from multiple sides. The exhibit *Flattering Physics?*, from *Eureka!*, is an example of an exhibit that

demonstrates this concept (see Figure 23). The exhibit consists of two double-sided bent mirrors. The nature of the mirrors allows one side to be convex and the other to be concave. Visitors can approach and engage with the mirrors from many angles.

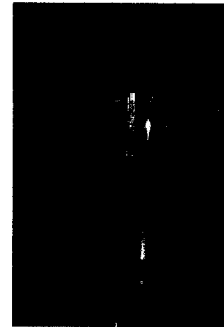
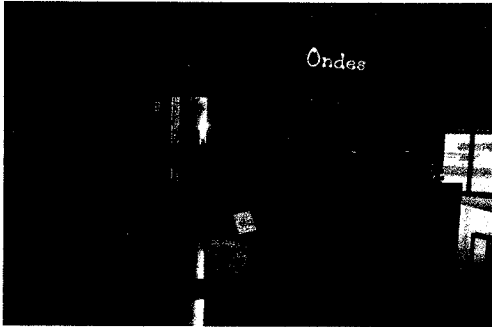


Figure 23: Flattering Physics?

4.1.3c Open: Interface(s) can be shared by multiple users

Exhibits where more than one visitor can access the interface(s) at one time are represented in this concept. An example of an exhibit that can be used by more than one visitor at a time is *Nailing The Challenge* from *Eureka!* (see Figure 24). Each of two stations consists of a large nail sticking vertically out of a table surface. The nail has a large head and text asks visitors how many other nails they can balance on it. Two visitors can try balancing the nails simultaneously.

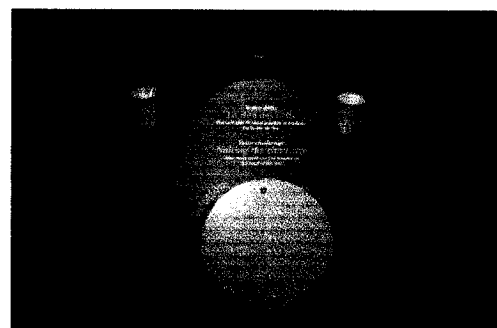
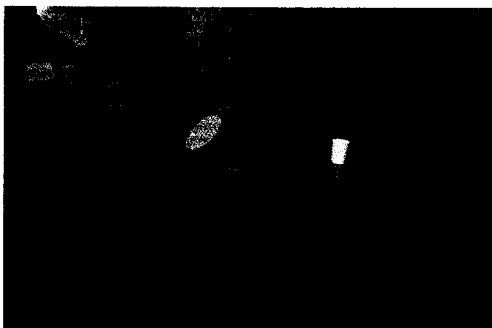


Figure 24: Nailing The Challenge

4.1.4 Physical Mechanics of Exhibit

The category named *Physical Mechanics of Exhibit*, qualifies the mechanical nature of an exhibit. The concepts are either: (a) *Static* or *Dynamic*, where *Dynamic* contains the sub-concepts (b) *Mechanical*, (c) *Analogue Electronic*, or (d) *Digital*. These concepts be examined in this section.

4.1.4a Static

Static exhibits consist of solely non-moving, non-changing elements. The exhibit *Maximum Amplitude*, from *X-Treme Rotation*, is an example of a *static* exhibit (see Figure 25). Visitors are presented with a life-size wall mounted graphic of a woman doing three different movements, each using a different joint. The movements are shown in an overlapping onion skin style and there are large rotation degree measures around the movements. Text invites visitors to try the movements and measure how far they can move (stretch) by lining themselves up with the wall. The exhibit contains no moving or changing elements.

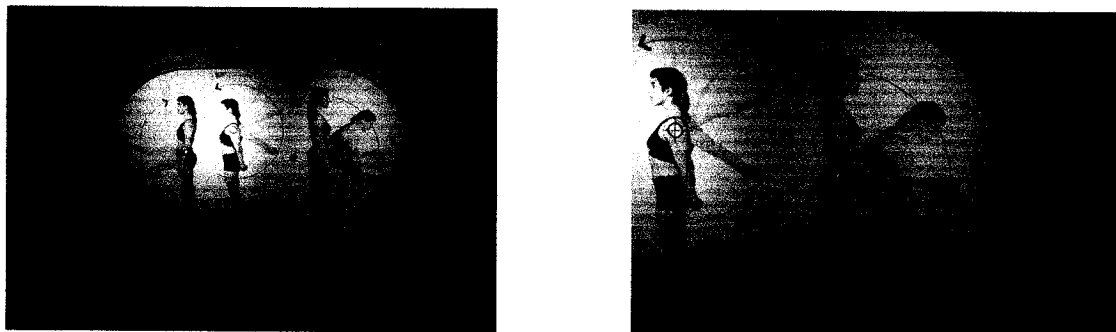


Figure 25: *Maximum Amplitude*

4.1.4b *Dynamic: Mechanical*

This concept applies to exhibits that have moving or changing elements that rely on physical forces and motion to function. The exhibit *Frrrrrriction!*, from *Eureka!*, is an example of an exhibit that functions *Mechanically* (see Figure 26). A tabletop has a row of seven rotating posts mounted on it. Between each post and the tabletop are two different materials. Visitors are invited by a text panel to try turning the posts. Some of the material combinations make turning the post very difficult and some make it easy. The exhibit relies entirely on physical forces and motion to function.

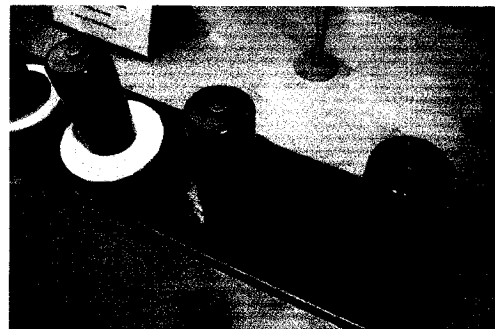
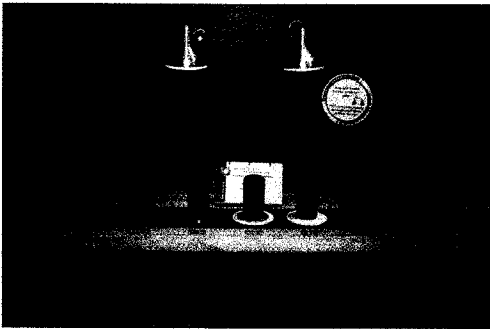


Figure 26: *Frrrrrrrriction*

4.1.4c *Dynamic: Analogue Electronic*

The concept identified as *Dynamic: Analogue Electronic* is present in exhibits that have moving or changing elements which function electronically by relying on a continuous spectrum of electrical values. An example of an exhibit that functions using *analogue electronics* is *Hop in the Saddle*, from *X-Treme Rotation* (see Figure 27). It consists of a post with three stationary bicycles attached to it. Each bicycle has a different gear ratio. An illuminated power meter for each bike on the top of the central column show the energy produced by a dynamo attached to each bike's wheel. The bikes and meters rely on *analogue electronics* to function.

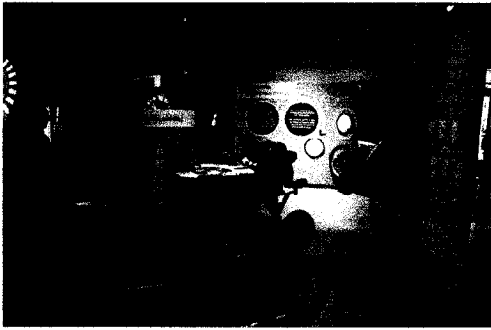


Figure 27: Hop In The Saddle

4.1.4d Dynamic: Digital

Exhibits with moving or changing elements that function electronically by relying on a system of numerical values, are *digitally Dynamic*. The exhibit *You've Got the Power*, from *Technocity*, is an example of an exhibit that functions using *digital* technology (see Figure 28). Using a mouse and monitor, visitors must match the electrical power needs of a community with electricity production. Two scenarios are presented in a software application: the first scenario involves matching the output of a generator to different appliances, while the second scenario involves matching the output of three power plants to a city. Over a simulated 24-hour period, demand for electricity changes and events like blackouts occur. Visitors must manage the output of the power plants quickly to succeed. The exhibit relies entirely on *digital* technology to function.

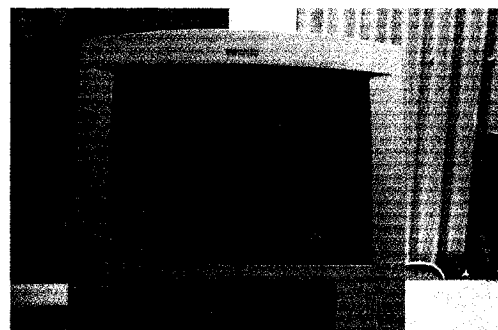


Figure 28: You've Got The Power

4.1.5 Physical Interface(s) of Exhibit

This category defines the nature of the interface between an exhibit and its visitors. The concepts are: (a) *Soft* and *Hard*, where *Hard* is either (b) *Electronic Control(s)*, (c) *Mechanical Control(s)*, and/or (d) *Direct Manipulation*. Each of these four concepts will be defined in this section.

4.1.5a Soft

The concept *Soft* is taken to designate controls that manipulate an exhibit created using non-permanent and changeable display technologies; for example, monitors or LCD (Liquid Crystal Display) panels. An example of an exhibit with a *Soft* interface is *Biped Born Bald* from *Eureka!* (see Figure 29). Visitors try a simplified version of gene therapy on a fictional cartoon character called a 'biped' that is born without feathers. The exhibit outlines a situation involving lacking genetic code in a biped that stops it from having feathers. Visitors choose genes until they find the one that is responsible for feather growth. They then match laboratory tools to the steps needed to produce a gene therapy treatment. If the visitor performs the steps correctly, the biped grows feathers. The interface of the exhibit is generated on a monitor by software, and visitors use a mouse to select buttons that are temporarily displayed on the screen. In this way, there are no permanent controls and the interface is entirely *Soft*, or adaptable, in nature.

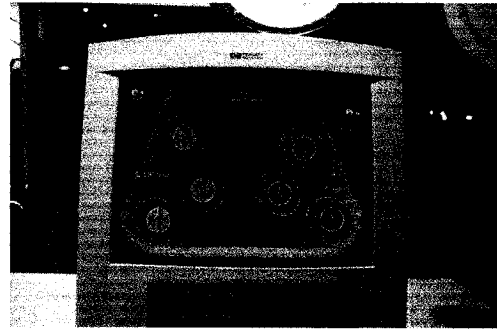
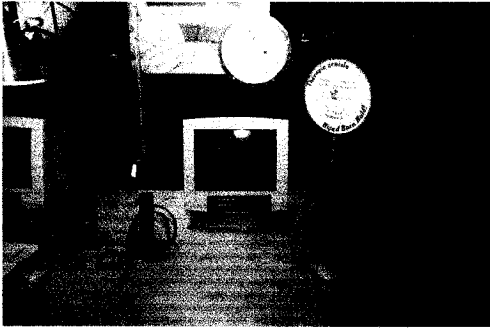


Figure 29: Biped Born Bald

4.1.5b Hard: Electronic Control(s)

Visitors use electronically functioning controls to manipulate an exhibit. These controls are labeled using permanent non-changeable technologies, like labels or paint. The exhibit *The Digital Revolution*, in *Technocity*, illustrates this concept (see Figure 30). An analog wave form is presented on an acrylic panel with a measured grid. Underneath the panel are columns of LEDs (Light Emitting Diodes) that correspond to the wave form. Each column lines up with a set of four switches that can be changed from one to zero and thus control how a series of LEDs lights up. When visitors enter the correct binary one and zero combinations to make the columns match the wave, all LEDs flash. The interface of this exhibit is permanent, non-changing, and functions electronically.

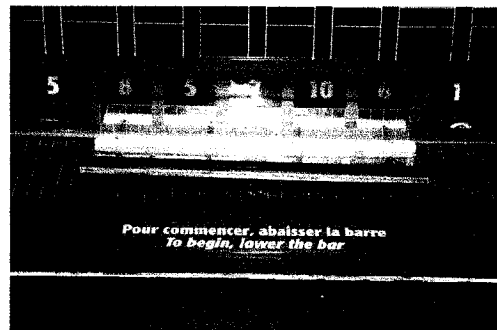
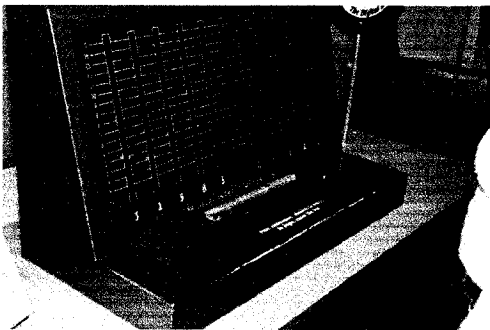


Figure 30: The Digital Revolution

4.1.5c *Hard: Mechanical Control(s)*

Controls that rely on forces and motion to operate, and are labeled using permanent non-changeable technology are represented in the concept *Hard: Mechanical Control*. An example of an exhibit with an interface that relies on *mechanical controls* is *Get The Wheels In Your Head Turning* from *X-Treme Rotation* (see Figure 31). Visitors are presented with a round area with posts protruding from it. Nearest the visitor is a gear with a handle that can be turned. Visitors choose from a selection of different-sized gears that fit on the empty posts. A sequence of gears can be created so that when the handle is turned, a patterned disk turns. The handle and the disk can be connected in a variety of ways demonstrating a variety of speeds and directions of rotation. The interface of the exhibit, the handle, is permanent, non-changing, and functions in a purely mechanical fashion.

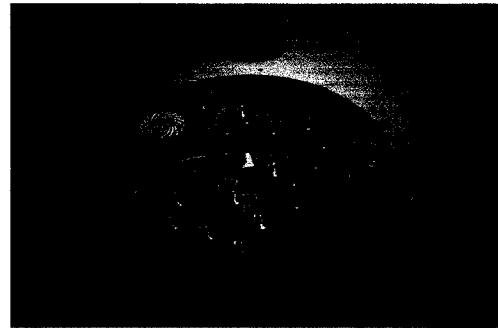


Figure 31: *Get The Wheels In Your Head Turning*

4.1.5d *Hard: Direct Manipulation*

The concept *Hard: Direct Manipulation* applies to exhibits that allow visitors to access and physically manipulate elements without intermediary controls or mechanisms. An example of an exhibit that allows visitors to *directly manipulate* its subject is *The Aluminum Reed*, from *Eureka!* (see Figure 32). A frame contains eight rods of different material. Each material is

repeated in rods of two different thicknesses. At the bottom of the frame is an open section where the rods can be pulled by visitors. A text panel invites visitors to pull and bend each rod and to feel the different resistance they give. In this way visitors are able to directly manipulate the reed without any intermediary mechanisms.

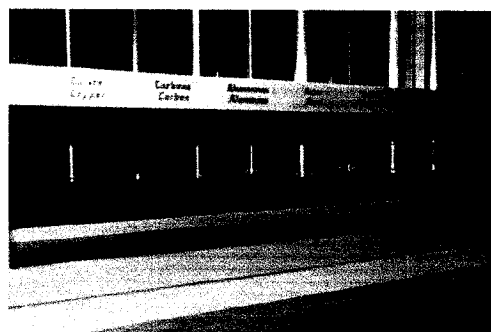
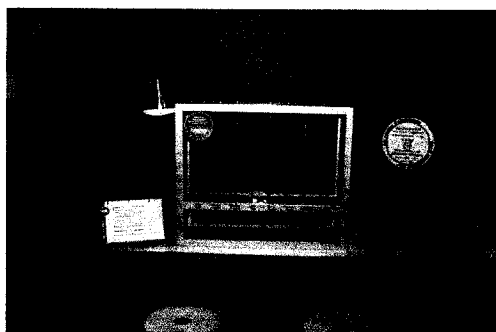


Figure 32: The Aluminum Reed

This section has outlined the categories that associate with the *Content* concept of the *pedagogical triangle*. Each concept within those categories was described and illustrated using example exhibits. The categories that relate to the *Learner* concept of the *pedagogical triangle* will be examined in the next section.

4.2 Learner Categories

The Learner dimension of the *pedagogical triangle* is analogous to the *Visitor* within museum settings. The categories address those features of the *physical context* of an exhibit that dictate the characteristics visitors must possess to interact as intended. These categories are: *Visitor Sense Implicated*, the perceptive ability that a visitor must possess to experience an exhibit as intended; and *Necessary Visitor Number*, the number of visitors and inter-visitor interactions

required for an exhibit to function as intended (see Figure 33). Since both of these concepts refer to visitor characteristics that are dictated by the *physical context*, they associate with the *Learner* concept of the *pedagogical triangle*. Each category and the concepts within them are discussed in the next sections.

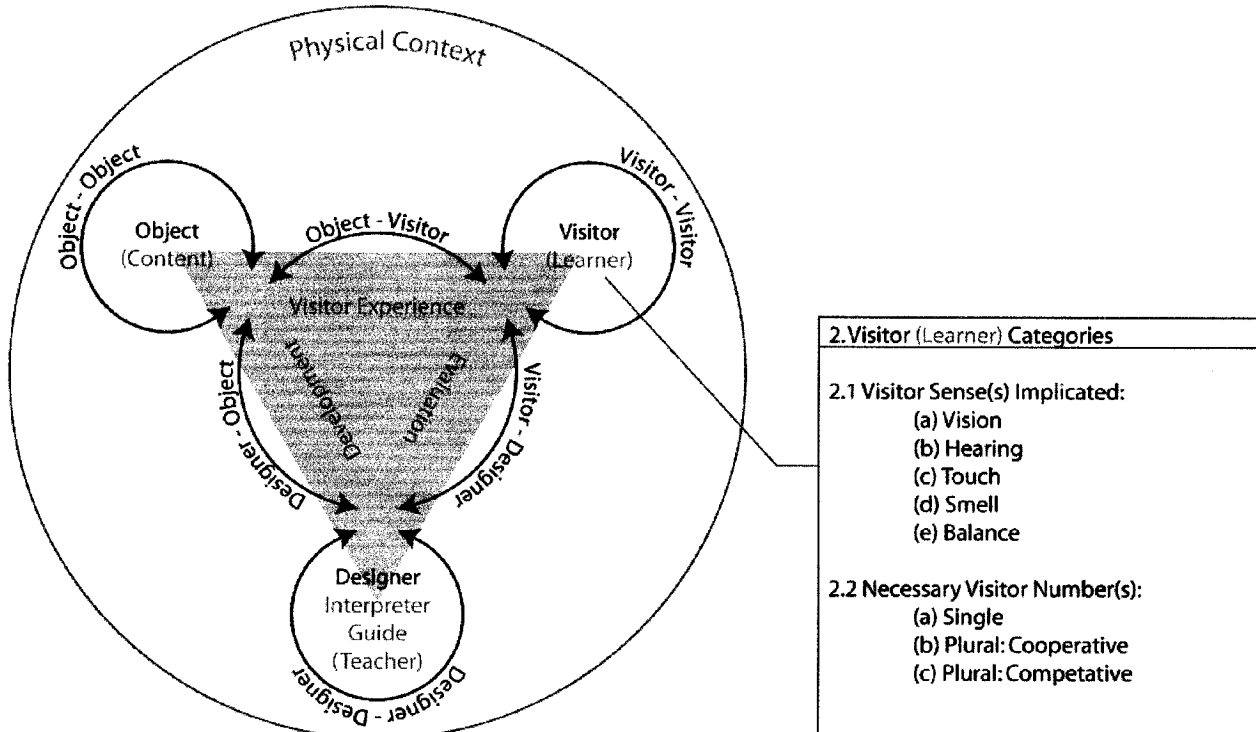


Figure 33: Learner Categories

4.2.1 Visitor Sense(s) Implicated

This category concerns the senses a visitor is expected to use. It contains the concepts: (a) *Vision*, (b) *Hearing*, (c) *Touch*, (d) *Smell*, and (e) *Balance*. They will be examined in this section.

4.2.1a Vision

In an exhibit that includes this concept, visitors use their ability to see. An example of an exhibit that demonstrates this concept is *Cyclorama* from *Eureka!* (see Figure 34). This large standing exhibit consists of a cabinet that encases two zoetropes, a simple device that allows a number of images to be viewed in sequence, creating the effect of movement. One zoetrope shows the sun and moon rising and falling in cycle. The other zoetrope shows a man rising and going back to sleep. Visitors must look at the zoetropes through small holes. Without sight, the exhibit cannot be experienced as intended.



Figure 34: *Cyclorama*

4.2.1b Hearing

Visitors are expected to have an auditory experience for an exhibit to function as intended. *Riding a Radio Wave*, from *Technocity*, is an example of this concept (see Figure 35). This exhibit consists of a showcase full of radio equipment. The case is divided in two with one side having transmission equipment and the other reception. Between the two sections is a divider that has a wheel mounted in it. The wheel protrudes out of the front of the case and can be turned by visitors. Half the wheel is empty and the other half is filled with a steel sheet. A knob below the reception side of the case can be moved from side to side and twisted. When it is

moved from side to side, an antenna on the reception side moves nearer and further from the centre wheel. When the knob is twisted the antenna rotates away from the wheel and back. An identical antenna is found on the transmission side of the wheel. When a start button is pressed a radio transmission begins. Visitors can adjust the steel plate and the reception antenna to hear the effect they have on a Morse code style sound that can be heard from a speaker. The less the radio signal is blocked by the rotating steel plate and the more the transmitting and receiving antennas are in line, the louder the visitor hears the sound. Without the ability to hear the sound, the exhibit would not function as intended.

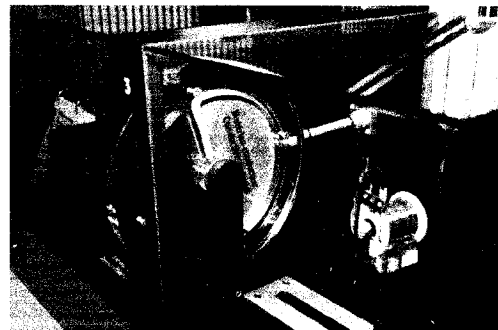
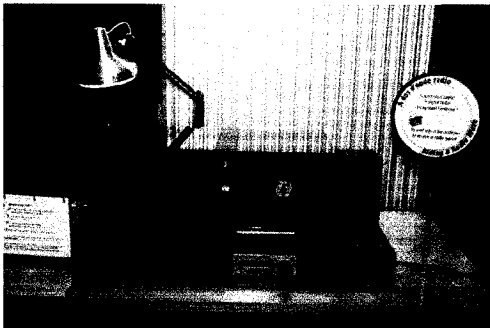


Figure 35: Riding a Radio Wave

4.2.1c Touch

When physical contact is needed for an exhibit to function as intended the concept *Touch* is referenced. An example of this is *Fakir School* from *Eureka!* (see Figure 36). This exhibit encourages visitors to try sitting in three different chairs, each with different numbers of nails for seats. As visitors sit on the seats with progressively fewer nails they feel the difference the number of nails make.

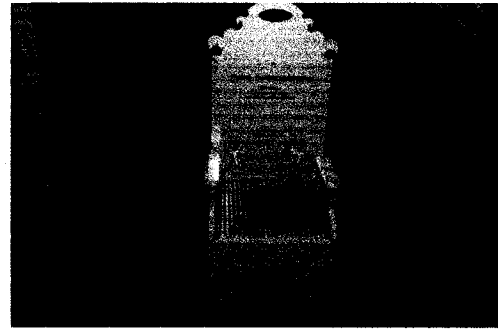


Figure 36: Fakir School

4.2.1d Smell

As a concept, *Smell* refers to situations where visitors must use their ability to perceive odour in an exhibit. The exhibit *Three Little Pigs*, from *Technocity*, is an example of such a situation. It was used as an example for the concept titled *Content Delivery Mode: Olfactory* (see Figure 16).

4.2.1e Balance

When visitors perceive changes in stability and orientation the concept *Balance* is implied. An example of such an exhibit is *Tightrope Walker* from *Eureka!* (see Figure 37). Visitors are presented with a large area of gym-style padded mats with a steel cable supported in tension above. The cable is split into two sections. One section has a railing that can be used for support and balance. The other section has no railing, but does have a long horizontal pole that can be lifted and manipulated. Visitors are invited to try balancing on the two sections of the cable using the assistance devices provided.



Figure 37: Tightrope Walker

4.2.2 Necessary Visitor Number(s)

This category applies to intended visitor numbers and to inter-visitor interactions while engaged with an exhibit. It involves the concepts (a) *Single* and *Plural*, with *Plural* divided into (b) *Cooperative* and (c) *Competitive* modes of interaction. Each one of these three concepts will be examined in this section.

4.2.2a Single

Single is indicated when an exhibit requires only one visitor to engage. *Invisible Chefs*, from *Technocity*, is an example of an exhibit that needs only one visitor to function (see Figure 38). It invites a visitor to match pictures of microbes, displayed in a lit magnifying lens, to different foods, displayed as back-lit images. Only one visitor is required for the exhibit to function as intended.

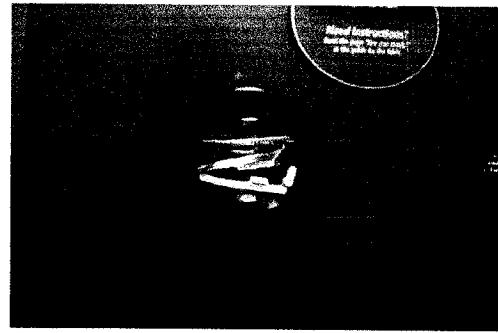
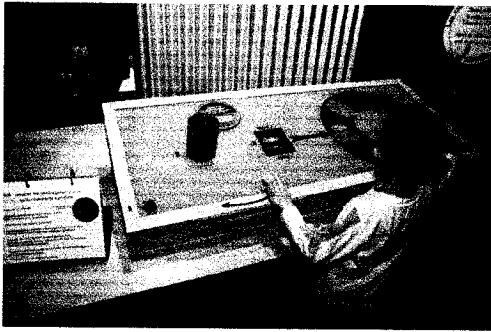


Figure 38: Invisible Chefs

4.2.2b Plural: Cooperative

This interaction involves more than one visitor working together towards a goal. An example of such an exhibit is *Talking Saucers* from *Eureka!* (see Figure 39). It consists of two large parabolic dishes at either end of the exhibition hall. Visitors speak into and listen from a disk mounted at the focus point of each dish and can have a conversation at whisper volume with visitors using the other disk. The visitors must work together to synchronize their conversation.

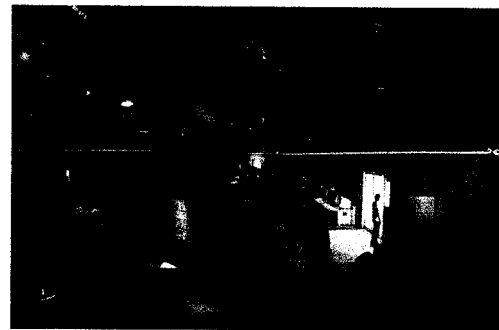


Figure 39: Talking Saucers

4.2.2c Plural: Competitive

Visitors are called upon to compete in this type of interaction. The exhibit *What's For Supper?*, from *Eureka!*, is an example of this (see Figure 40). When visitors press on a 'Question' button, one of twelve boxes lights-up at random. On the lit box appears a picture of a food and a

question about its nutritional value. Answers to the question are labeled 'A' or 'B' corresponding to two buttons. Two visitors at a time are invited to try pushing the correct button first and each receive a green or red light depending on their answer. Each visitor counts their correct responses using an abacus style counting system. Once all the questions have been answered a winner is determined.

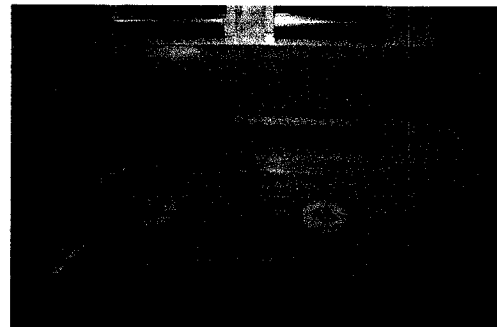
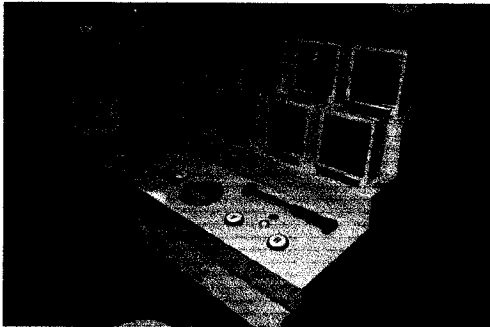


Figure 40: What's For Supper?

The categories that refer to the *Learner* concept of the *pedagogical triangle* were examined in this section. All the concepts within those categories were described and illustrated using example exhibits. The next section will examine the categories that associate with the interaction existing between the *Content* and the *Learner* concepts of the *pedagogical triangle*.

4.3 Content – Learner Interaction Categories

The interactions between the *Content* and *Learner* concepts of the *pedagogical triangle* correspond, in museum settings, to the interaction between the exhibits and the visitors. Associated to this *Content – Learner Interaction* are those categories identified from the *physical context* as being not immediately present when an exhibit is in its resting state, but manifested

when a visitor is interacting with it. These categories comprise: *Task Activity*, the set of actions that visitors undertake in the exhibit experience; *Task Path*, the order with which visitors perform actions to experience an exhibit as intended; and *Task Outcome*, the conclusion to an exhibit's activity if used as intended (see Figure 41). Each category refers to the characteristics, identifiable from the *physical context* of an exhibit, that are only present when visitors are engaged. They, therefore, relate to the *Content – Learner Interaction* of the *pedagogical triangle*. All three categories and the concepts revealed will be described in the sections that follow.

3. Object - Visitor (Content - Learner) Interaction Categories		
3.1 Task Activity(s):	3.2 Task Path(s):	3.3 Task Outcome(s):
(a) Question/ Answer	(a) Open	(a) Open
(b) Exploration	(b) Pre-defined: Single	(b) Pre-defined: Single
(c) Investigation	(c) Pre-defined: Multiple	(c) Pre-defined: Multiple
(d) Observation		

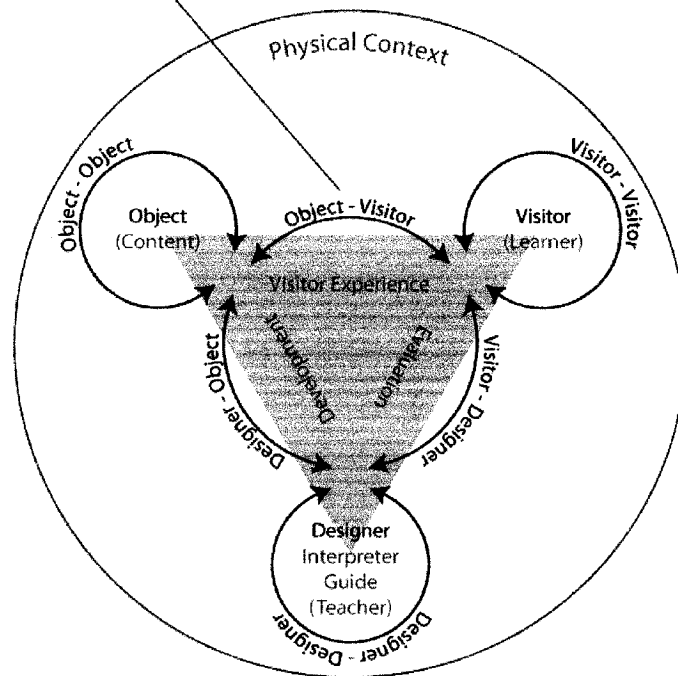


Figure 41: Content - Learner Interaction Categories

4.3.1 Task Activity(s)

This category refers to the type of task which visitors are invited to engage in. It contains the concepts: (a) *Question/Answer*, (b) *Exploration*, (c) *Investigation*, (d) *Observation*, and (e) *Creation*. Each concept is addressed in this section.

4.3.1a Question & Answer

In the *Question & Answer* format visitors are questioned and invited to answer. This includes a number of sub-formats including, open answers, matching, and multiple choice. An example of an exhibit that has *Question and Answer* as its *Task Activity* is *Chameleon Houses*, from *Eureka!* (see Figure 42). Visitors are invited to match different house types to their respective environments. A painted panel presents five different environments in a montage. Each environment is represented by a small amount of landscape and an individual in culture-specific dress. These environments each have a blank patch which must be filled by a house. Visitors have five different types of houses to choose from, one specific to each of the environments in the montage. Each house is presented on a foam panel with a steel insert. If the house is placed correctly it sticks, if it is placed incorrectly it falls off.

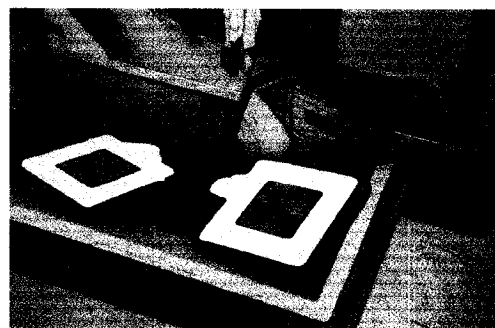
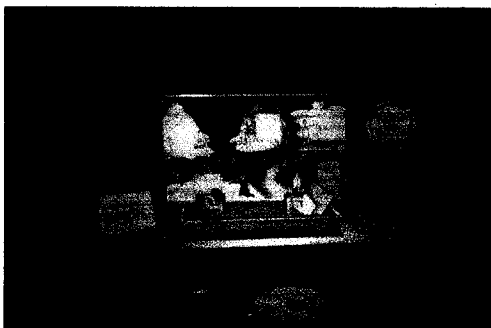


Figure 42: *Chameleon Houses*

4.3.1b Exploration

Open inquiry and examination are probed in this concept. The exhibit *Tornado Simulator*, from *X-Treme Rotation*, is an example of *Exploration as Task Activity* (see Figure 43). It consists of a tower that is constructed with thick disks at either end and has four posts between them. The bottom disk has a grill through which smoke emerges and each post has a fan attached to it. As the smoke rises from the base, the fans on the posts swirl it, eventually creating a small tornado. As the exhibit is completely open and unrestricted, visitors' are able to directly touch and manipulate the smoke. Visitors' explore the effects of disturbing the air patterns between the posts, and as they do so, they change the shape of the tornado.



Figure 43: *Tornado Simulator*

4.3.1c Investigation

The concept *Investigation* engages the visitor in a process of systematic formal inquiry. *Deposit Detection*, from *Technocity*, is an example of this concept (see Figure 44). Visitors are presented with a box of sandy soil enclosed in a glass case with grid lines on it. Above the box is a magnetic sensor that can be moved both vertically and horizontally along the surface. Visitors move the sensor over the soil. If the sensor passes over a buried mineral, a volt meter that is attached to the sensor reacts. The closer the sensor is to a mineral, the stronger the reading. Text

invites visitors to mark down their findings on a piece of paper, making a map of the minerals in the soil. A reveal button can be pressed that lights up all the minerals and their locations. To complete the activity, visitors must systematically find each of the hidden minerals.

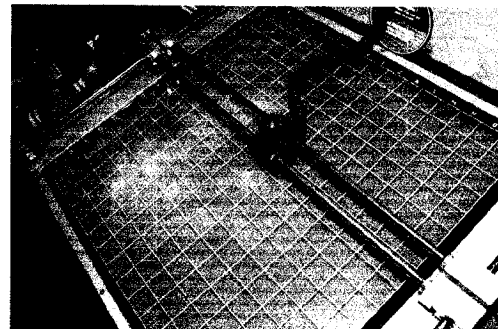
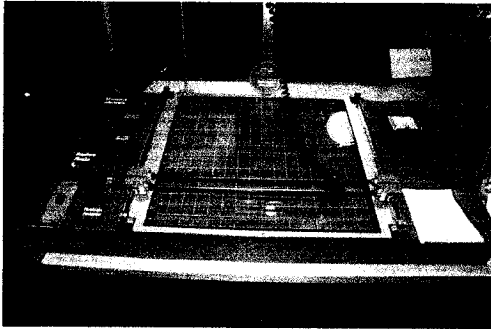


Figure 44: Deposit Detection

4.3.1d Observation

An activity that solely intends visitors to closely examine an exhibit's content invites *Observation*. An example of an exhibit that has *Observation* as its *Task Activity* is *Take a Look at a Chip Under a Microscope* from *Technocity* (see Figure 45). It consists of two microscopes mounted on a tabletop. Under one of the scopes is an aluminum computer chip, under the other is a copper computer chip. A button beside each scope turns on a light so the chips can be seen clearly. Visitors are invited, by text, to observe each chip under the scopes.



Figure 45: Take a Look at a Chip Under a Microscope

4.3.1e Creation

Creation orients visitors to engage in a process of invention, including artistic and construction activities. The exhibit *Creation in Motion*, from *X-Treme Rotation*, is an example of *Creation* (see Figure 46). Visitors are presented with a software program that controls the dancing of animated figures. They can choose from a selection of dance moves and see those moves performed graphically. They can then select a sequence of four dance moves while listening to music on headphones. Once created, visitors' dance sequences are displayed on a large projected screen for others to see.

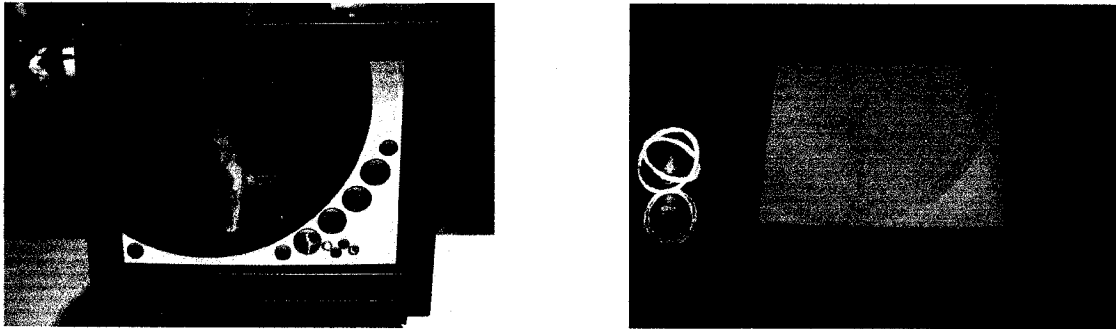


Figure 46: *Creation in Motion*

4.3.2 Task Path(s)

The steps for visitors to perform while engaged with an exhibit's activity are encompassed in the category named *Task Path*. The concepts of (a) *Open* and *Pre-defined* are contained within *Task Path(s)*, with *Pre-defined* allowing for either (b) *Single* or (c) *Multiple Paths*. These concepts are next described.

4.3.2a Open

Open exhibits have no pre-determined steps defined for visitors to follow. An example of an exhibit that has an *Open Task Path* is *Higher and Higher* from *Eureka!* (see Figure 47). Visitors can choose either large or small wooden blocks and build a tower using one of three hard floor plates as a base. How the blocks are used is decided by the visitor.

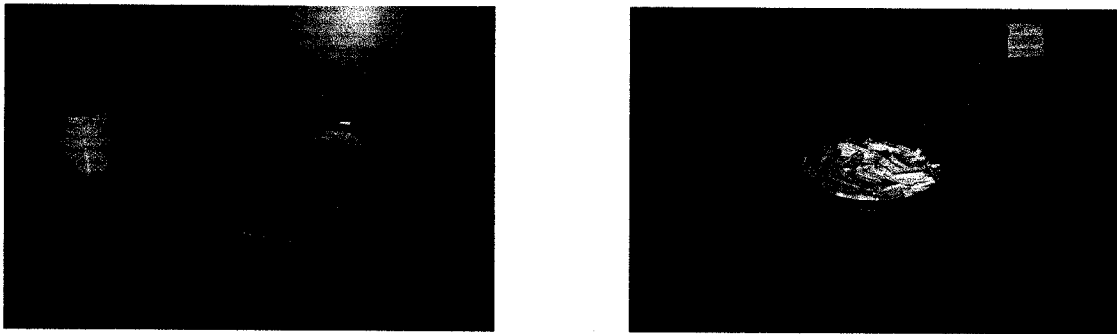


Figure 47: Higher and Higher

4.3.2b Pre-Defined: Single

When one unique pre-determined set of actions must be followed, this concept is evoked. *Into the Gene Pool*, from *Eureka!*, is an example of such an exhibit (see Figure 48). This mouse and monitor-based digital exhibit is based on the gene process needed for a child to be born albino. Each mouse click a visitor moves them to the next point in the story. The genetic story of how an albino child occurs is presented in an animated fashion with pauses throughout. Each time there is a pause the visitor must click something on the screen to continue.

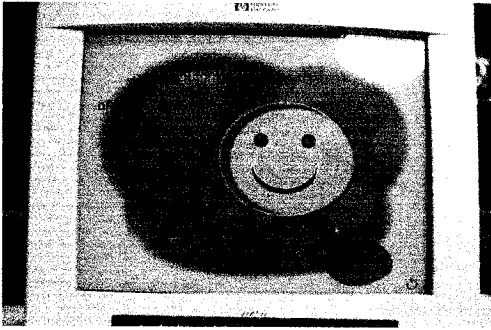


Figure 48: Into The Gene Pool

4.3.2c Pre-Defined: Multiple

Exhibits that demonstrate this concept have several unique pre-determined paths that lead to the end of their activity. An example of an exhibit with *Multiple* pre-determined *Task Paths* is *The Macro Microphone* from *Technocity* (see Figure 49). Protruding from the front of three showcases is a knob or mesh-covered hole. Each showcase has a piece of electronics in it and a volt meter. The first case has a wrapped coil and when its knob is rotated, a voltage is produced. The second case has a large speaker and when its knob is pushed in and pulled out, the speaker moves creating a voltage. The third case has a microphone, into which sounds can be thus creating a voltage. For each case, the visitor must perform a pre-determined action, though the action at each case is different.

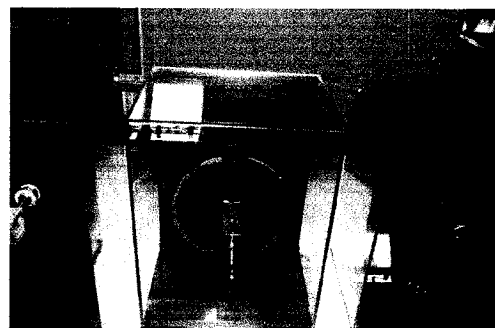


Figure 49: The Macro Microphone

4.3.3 Task Outcome(s)

With the completion of an exhibit's *activity*, following an intended *path*, comes a conclusion. This category comprises: (a) *Open*, (b) *Pre-defined: Single* and (c) *Pre-defined: Multiple Outcomes*. Each concept will be examined in this section.

4.3.3a Open

When no pre-determined outcome for an activity is offered an *Open* outcome is possible. In this case, visitors' choose when and how to conclude an activity. *A Question of Balance*, from *Technocity*, is an example of an exhibit that has an *Open Task Outcome* (see Figure 50). Visitors are invited to create paper airplanes and test them using a table mounted fan. Once they have created an airplane they can then fly it in a dedicated flying area of the exhibition. The kind of plane, how it flies, and for how long is decided by the visitor.



Figure 50: *A Question of Balance*

4.3.3b Pre-Defined: Single

Exhibits orient towards this concept only have one intended conclusion to their activity. An example of this is *Pitch In* from *X-Treme Rotation* (see Figure 51). It consists of two disks mounted on horizontal threaded rods. The disks can be spun *in order to move* along the threads

of the rods. One pole has a fine thread and the disk moves slowly, the other has a coarse thread and the disk moves quickly. The intended *Outcome* of the exhibit occurs once the visitors have tried both disks.

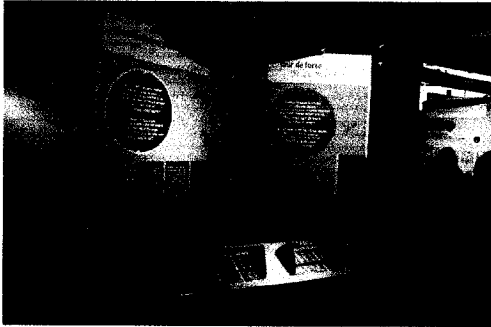


Figure 51: Pitch In

4.3.3c Pre-Defined: Multiple

An exhibit engenders this concept if there is more than one unique intended *Outcome* to an activity. *Trace That Call*, an exhibit from *Technocity*, is an example of *Multiple Task Outcomes* (see Figure 52). Visitors choose between connecting a phone in Montreal to a phone in Paris or to a cell phone in New York. Visitors must match the correct telecommunications equipment, in the correct order, to each step in a call's journey. Each of the two calls has a distinct *Outcome*.

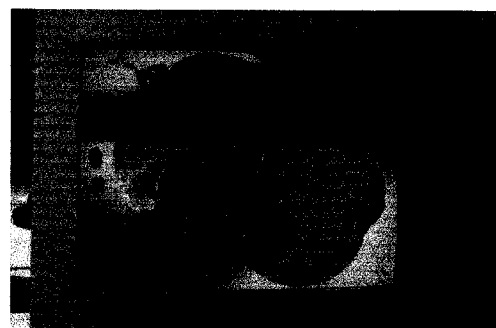


Figure 52: Trace That Call

The preceding three sections have identified each of the categories and concepts that emerge from the examination of the *physical context* of the hands-on interactive exhibits at *Montreal Science centre*. The categories were organized into three groups that correspond to three concepts of the *pedagogical triangle*: the *Content*, the *Learner*, and the *Content – Learner Interaction*. Each concept within the categories was illustrated using an example exhibit. In the next section, the complete set of categories and concepts will be presented as a synthesized schematic diagram.

4.4 Synthesized Schematic Diagram

To illustrate the complete structure of organized categories and concepts identified in hands-on interactive exhibits, a schematic diagram is presented (see Figure 53, below). This diagram shows both the use of the *physical context* as a lens through which to examine the hands-on interactive exhibits, and the resulting organization of emergent categories and concepts based on the *pedagogical triangle*.

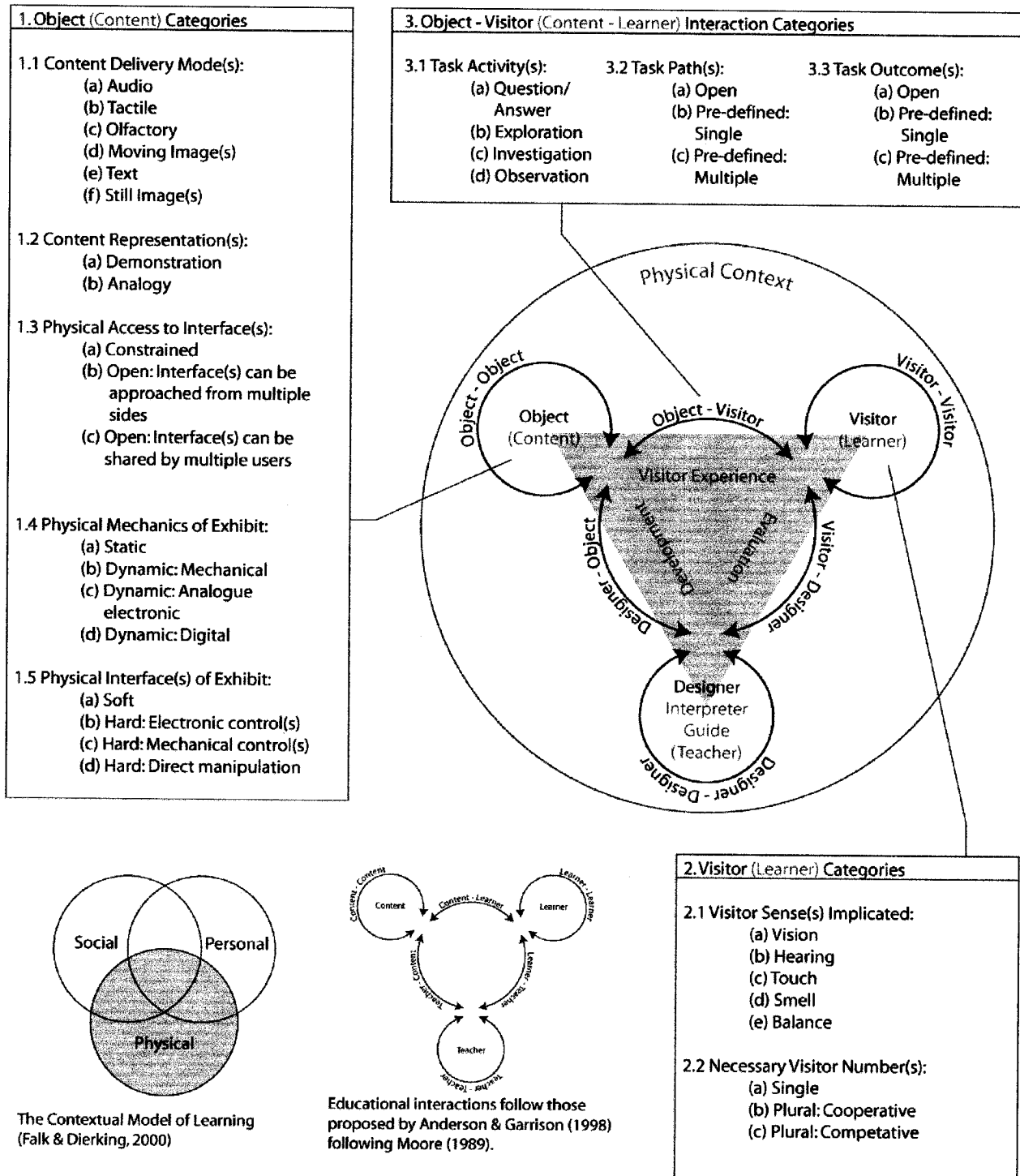


Figure 53: Synthesized Schematic Diagram

4.5 Conclusion

This chapter has presented the findings from an examination of the *physical context* of the hands-on interactive exhibits in three exhibitions at the *Montreal Science centre*. First, the categories and concepts aligned to the *Content* were addressed using illustrative examples; second, those categories and concepts that relate to the *Learner* concept were identified; and third, the categories and concepts that refer to the interaction between the *Content* and *Learner* were described. Finally, a synthesized schematic diagram was used to summarize and illustrate the complete structure of organized categories and concepts. In the next chapter, the relevance of these findings will be discussed.

5. Discussion

In this chapter, the relevance of the present study will be discussed. Following a section addressing the conceptual framework, each of the categories related to the implicated concepts of the *pedagogical triangle* will be used as a basis to explore the relevance and implications of the overall study. First, issues related to the *Content* categories; second, the *Learner* categories; and finally, those categories that associate with the interaction between the *Content* and *Learner* will be examined.

5.1 Discussion of the Conceptual Framework

In this section, the relevance of the *conceptual framework* of this study will be examined. The framework is developed from the central question: what categories and concepts emerge from the *physical context* of hands-on interactive exhibits when a *pedagogical perspective* is taken. Both models that compose the conceptual framework are widely used: Falk and Dierking's (2000) *Contextual Model of Learning* in the study of informal learning experiences, and the *pedagogical triangle*, in the study of educational processes. This wide applicability is one of the major factors influencing the relevance of the findings of this study. For example, the application of the *physical context* of the *Contextual Model of Learning* allows the findings to be related to other studies that use the same model as a framework. Findings from other studies that examine hands-on interactive exhibits through different contexts of Falk and Dierking's (2000) model, while perhaps not directly comparable, could be associated to the present study with the

understanding that the frame the model provides is a point of reference between sets of findings. Similarly, the model of the *pedagogical triangle* provides a common reference for the findings of this study and other studies of educational processes. Though this study deals exclusively with hands-on interactive exhibits as learning opportunities, the identified categories and concepts refer to the *pedagogical triangle* and could therefore be related to other learning opportunities examined using the same structure. The conceptual framework of the present study situates the findings, providing a point of reference that increases their relevance. Each category identified in the findings will be discussed in the next three sections, beginning with the categories associated with the *Content* concept of the *pedagogical triangle*, then following with those related to the *Learner* and, finally concluding with those pertaining to the *Content – Learner Interaction* categories.

5.2 Discussion of the Content Categories

As is to be expected in an examination of the *physical context* of hands-on interactive exhibits, the largest number of categories appears in relation to the *Content* concept of the *pedagogical triangle*. Since, in the case of museum exhibits, the *Content* is the exhibit itself as an object, the categories that relate to it are those that are most immediately evident and those that remain the same regardless of state. The characteristics of an exhibit that pertain to these categories are those that are responsible for attracting and initially engaging a visitor's attention. Sandifer defines this phenomenon in terms of how it can be measured: "Attracting power is typically defined as the percentage (or fraction) of visitors who stop at a given exhibit for a

minimum amount of time” (Sandifer, 2003, p. 122). Further examination of hands-on interactive exhibits from the perspective of the *personal* and *social* contexts of the *Contextual Model of Learning* might yield insights into other attracting powers of exhibits. Since this is outside the scope of this study, it is fair to say based on the findings that any attracting power derived directly from the *physical context* of an exhibit is associated with those categories and concepts related to the Content. These categories are therefore particularly relevant to the learning experiences of visitors since without an effective ability to attract visitors, exhibits present few opportunities for learning to occur.

Beyond their role in attracting visitors' attention, the categories that relate to *Content* make up important components of hands-on interactive exhibits. While all of the categories are important to an exhibit's design, it is the *Content* categories that fall most directly within the realm of the gross aesthetic and mechanical form of an exhibit. This makes these categories particularly relevant to the designers responsible for the architectural nature of an exhibit. These are the elements that help set the tone for visitors' experiences both with an individual exhibit and within an overall exhibition. Each of these categories, *Content Delivery Mode*, *Content Representation*, *Physical Access to Exhibit*, *Physical Mechanics of Exhibit*, and *Physical Interface of Exhibit* will be discussed in this section.

5.2.1 *Content Delivery Mode(s)*

The *Content Delivery Mode (Audio, Tactile, Olfactory, Moving Image, Text, and Still Image)* concerns technologies employed to convey an exhibit's content to visitors. As such, this category is particularly relevant to other forms of learning opportunities that use similar

technologies. For instance, the use of *Text* to communicate content relates strongly to other forms of textual presentation, like books or signs. Research conducted on the use of text to deliver content in learning situations may have implications for the use of text in exhibits. This research might include insights into characteristics such as sentence structures, tone, or even font. In the same fashion, but with newer technology, the use of computer terminal-style exhibits, that make use of the concepts of *Moving Image(s)*, *Audio*, and *Text* within this category, relates directly to web or PC-based learning applications. Many museums, in fact, design computer terminal-style exhibits so that their software can be repackaged for the museum's website. Research that relates to web or PC based learning applications may also be relevant to hands-on interactive exhibits that use similar technology to deliver content. In this way, the concepts that are encompassed by the category titled *Content Delivery Mode* are particularly relevant to other learning opportunities that use similar technologies.

5.2.2 *Content Representation(s)*

The distinction between the types of content identified, *Demonstration* and *Analogy*, is largely based on Gentner's (1989) model of analogy. His model consists of three distinct levels: 'simple demonstration', 'close-analogy', and 'far-analogy'. For the purposes of the findings, this was simplified to only two levels. In Gentner's model, 'close-analogy' is a 'mere-appearance match'. That is an analogy where only the general attributes and number of objects in the source phenomenon or subject match the target or, in this case, the exhibit. 'Far-analogy', is based on Gentner's concept of 'analogy similarity' where there is no similarity between the objects in the real world phenomenon and the target, or exhibit, representation. In this case, the only analogy that can be made is between the relationships of the real world objects and the relationships of

the represented objects (Gentner, 1989). While examining the hands-on interactive exhibits in the three exhibitions at the *Montreal Science Centre*, it was determined that though examples of 'simple demonstration' existed, those exhibits that showed analogous relationships between subject and representation were part of a complex continuum of levels and types of analogy dominated by 'close-analogy'. Therefore it was decided to simplify Gentner's model and only delineate between *Demonstration* and the broader concept of *Analogy*.

5.2.3 *Physical Access to Interface(s)*

A major limitation of this category is that it only describes planned access and not unintended access. Though an exhibit might be *constrained* by design, physically removing the possibility for more than one visitor to engage at a time, there is still the possibility of indirect engagement by other visitors at the same time. For instance, if a visitor is looking into a telescope and answering questions about what he sees, it may be impossible for another visitor to look at the same time. This design does not prohibit visitors taking turns during the course of the exhibit's activity or one visitor describing what can be seen to another and asking for help with the questions. This type of unintended use cannot be observed from the *physical context* of an exhibit and must therefore be examined from the *personal* or *social* contexts. While several categories in both the *Learner* and *Content - Learner Interaction* groups are limited by their inability to identify unintended visitor behavior, *Physical Access to Interface* is the sole category within the *Content* group for which this limitation exists.

5.2.4 *Physical Mechanics of Exhibit*

Especially relevant to the category called *Physical Mechanics of Exhibit* are the changes occurring with *Dynamic: Digital* exhibits. All the concepts in this category, *Static, Dynamic: Mechanical, Dynamic: Analogue Electronic*, and *Dynamic: Digital*, are susceptible to changes in technology and re-imaginings of their possibilities. *Dynamic: Digital*, in particular, is affected by the rapid changes present in digital technologies. As the prevalence and scope of digital technologies increases in exhibitions, the nature of the visitor's experience changes. The content and subjects that can be addressed by designers through hands-on interactive exhibits also changes: where before content might have been too abstract or too difficult to produce mechanically, leading to static exhibits, with the use of digital technologies new options have emerged. Along with this expansion in the options available to designers has come the opportunity to include hands-on interactive exhibits in wider variety of exhibitions. The first examples of such exhibits were found exclusively within purpose-built science centres like the *Exploratorium*, but were then quickly added to traditional museums within distinct hands-on interactive exhibitions like *Launch Pad* at the *London Science Museum*. Recently, partly as a result of more options for designers, a trend towards including hands-on interactive exhibits within traditional exhibitions in combination with static exhibits has emerged. This type of use opens many new possibilities for the inclusion of hands-on interactive exhibits but also raises questions. If such exhibits are to be included at the same level of exhibition planning as static exhibits, and not kept entirely distinct, where is their use appropriate? This and other similar questions are a rich field of possible research that would be valuable in helping to inform exhibition designers' choices.

5.2.5 *Physical Interface(s) of Exhibit*

In many ways, the relevance of this category to broader fields of research is similar to that of the category named *Content Delivery Mode*. There exists a direct relationship between the types of interfaces employed in hands-on interactive exhibits, as represented in the concepts of this category, and other applications of the same or similar types of interface. Examinations of *Hard: Electronic Controls* versus *Soft* interfaces on bank machines, for instance, may have implications for the use of those types of interfaces in hands-on interactive exhibits. Similar to both the categories *Content Delivery Mode* and *Physical Mechanics of Exhibit*, this category is susceptible to changes in technology. The concepts defined within this category are representative of that which emerged at the *Montreal Science centre* at a certain time. Particularly for these three categories, new technologies may require the addition of concepts in the future. Along with other technology-susceptible categories, *Physical Interface of Exhibit* must evolve with changes in technology to remain relevant to the practice of exhibition.

Each of the categories encompassed in the *Content* have been discussed in this section. In a similar fashion, those categories related to the *Learner* will be discussed next.

5.3 *Discussion of Learner Categories*

The categories that relate to the *Learner* concept of the *pedagogical triangle* are the least numerous of the three groups. This relatively sparse amount of information is due to the focus of this study: the *physical context*. By solely examining the *physical context* of hands-on interactive exhibits, visitors' behavior while interacting with an exhibit was outside the scope of the study.

The two categories that do relate to the *Learner* represent the influence an exhibit's *physical context* exerts over the disposition of a visitor to be open to an experience. For example, for a visitor to engage with a screen based exhibit, they must have the ability to see. Without this ability or an alternative form of content delivery, the exhibit will not be engaging for that visitor. In this way, these categories are relevant to exhibition designers in that they highlight the accessibility of an exhibit. Accessibility is one of the most important issues in modern museum exhibitions since museum administrations often have, as a primary goal, the inclusive service of individuals with disabilities. Since many museums are publicly funded institutions, they must follow the rules that governments have associated with their funding. For example, both the American Disabilities Act (US Department of Justice, 1994) and UK Disability Discrimination Act (Queen's Printer of Acts of Parliament, 1995), for instance, apply directly to museum exhibitions and require that visitors with disabilities have 'reasonable' access to exhibits. How the term reasonable is understood is defined differently in each document, but the general spirit that museum exhibitions must be open to visitors with disabilities is part of the requirements of both.

Apart from the relevance of the *Learner* categories in highlighting the need for accessibility in exhibitions, they are also important in demonstrating the possibilities for further research on exhibits. Many more refined categories could emerge if a set of hands-on interactive exhibits was examined, for example, through the lens of the *personal context*, from Falk and Dierking's *Contextual Model of Learning* (2000). By using the same conceptual framework identified in this study, but focusing on a different context, much could be added to this set of categories and concepts. Some of this work could be accomplished with a thorough survey of existing research in relation to the framework, although a good deal of new examination would

likely be required for a complete picture to emerge. Those categories related to the *Learner* that have been identified from the *physical context*, *Visitor Sense Implicated* and *Necessary Visitor Number*, will be discussed in this section.

5.3.1 *Visitor Sense(s) Implicated*

This category links to the *Content* category *Delivery Mode* in that it deals with the reception of delivered content and evokes two major issues. First, the possibility for the senses to be implicated by hands-on interactive exhibits beyond those at *Montreal Science centre*; and second, accessibility for visitors with disabilities. During expert consultations associated with the validity and reliability of this study, two senses in particular were raised beyond those that had already been identified. Both taste and spatial orientation were suggested as senses that might be implicated by hands-on interactive exhibits in other museums. While spatial orientation seems immediately applicable and plausible, the concept of including elements that must be tasted in a museum exhibition raises a number of functional problems. The possibility for these senses to be implicated by other exhibits outside those present at *Montreal Science centre*, highlights the evolving nature of the concepts within this and several other categories. As new exhibits are developed, new concepts could be added, strengthening the findings of this study. The second major issue relevant to the *Visitor Sense Implicated* category is the accessibility of exhibits for visitors with disabilities. By identifying the senses implicated, this category informs on which types of disabilities will render visitors unable to experience an exhibit as intended. This underscores the need for exhibits to use multiple senses in planning an experience.

5.3.2 *Necessary Visitor Number(s)*

The category *Necessary Visitor Number* includes the concepts, *Single, Plural: Cooperative* and *Plural Competitive*. One of the major limitations of this category is that it does not encompass unintended visitor interactions, although it is possible to determine from the *physical context* of an exhibit whether it has been designed for use by an individual visitor or for simultaneous use by multiple visitors. It is also possible to identify certain types of intended inter-visitor interactions, but not all. In particular, while it is evident when an exhibit requires visitors to interact cooperatively or competitively to function as intended, it is not possible to determine if other forms of interaction, like sharing, will occur. In order to identify these types of interactions, examinations of the *Personal* and *Social* contexts shall have to be made in further research.

This section has discussed the two categories, *Visitor Sense Implicated* and *Necessary Visitor Number*, that pertain to the *Learner*. The next section will discuss those categories related to the *Content – Learner Interaction*.

5.4 *Discussion of Content – Learner Interaction Categories*

Between the *pedagogical triangle* concepts of the *Content* and the *Learner* exists an interaction associated with three of the categories identified, namely: *Task Activity*, *Task Path* and *Task Outcome*. In each case, these categories refer to the task that visitors perform when engaging with an exhibit. Unlike the concepts associated with the *Content* categories which are immediately evident in an exhibit, the categories that relate to the *Interaction*, though also

dictated by the *physical context*, are only salient when a visitor is engaged as intended. For example, if an exhibit is *mechanical* in nature, a concept associated with the *Content*, it will always be *mechanical* regardless of its state of activity or visitor interaction. The intended *Path* of an exhibit's activity, however, may be articulated in the *physical context* of that exhibit but requires visitors to be engaged. These categories are particularly relevant to researchers and designers because they identify the intentions exhibition designers have for visitors' behavior. It is in the way in which these categories function that many of the characteristics that contribute to the success or failure of an exhibit as a learning opportunity can be found. Since designers have no direct influence over a visitor's behavior, they must rely on the manipulation of these characteristics to design the experiences they intend. Each of the categories associated with the *Content – Learner Interaction, Task Activity, Task Path* and *Task Outcome* will be discussed in this section.

5.4.1 Task Activity(s)

This category includes the possible types of activities that can be included in an exhibit. Since these concepts are limited to those identifiable in three exhibitions at *Montreal Science centre*, there exists the possibility that others could be added from other exhibitions. As with the other categories associated with the *Content – Learner Interaction, Task Activity* relies on the compliance of visitors. If visitors choose not to perform the activity the resulting activity type cannot be predicted from the *physical context* of the exhibit. Perhaps more than other categories, this category pertains to the age and ability of visitors. Exhibition designers must choose carefully the activity for an exhibit based on the age and ability of visitors. As with other categories, research that examines the suitability, for different ages and abilities, of the activity

types included as concepts in this category, would provide information to exhibition designers making decisions on which activities to include in exhibits.

5.4.2 *Task Path(s)*

Task Path contains three concepts: *Open*, *Pre-defined Single*, and *Pre-defined Multiple*.

Though each path has its place in different sorts of exhibits, an *Open Task Path* has been identified as being particularly beneficial in holding visitors' attention while engaged with an exhibit. This is addressed in Sandifer's (2003) study where he uses the term 'Open-ended' to describe exhibits where one or many goals can be achieved in a variety of different ways, decided by the visitor (Sandifer, 2003). Using measures of the length of time visitors were engaged with an exhibit, Sandifer shows that *Open Task Path* exhibits tend to hold visitors' attention for longer than those that have pre-defined paths. This is a particularly relevant example of the kind of research that, once situated by the findings of this study, can help to build a more complete picture of learning and hands-on interactive exhibits while informing the practice of exhibition design.

5.4.3 *Task Outcome(s)*

The category *Task Outcome (Open, Pre-defined: Single and Pre-defined: Multiple)* strongly pertains to a visitor's motivation to complete an exhibit activity. Since there exist very few situations in a museum where visitors experience any external motivation to interact with an exhibit, exhibition designers must rely on visitors' intrinsic motivation to engage in an activity (Csikszentmihalyi and Hermanson, 1995). Though visitors are initially attracted to a particular exhibit through curiosity and interest, the exhibit must quickly reinforce the visitor to maintain

their attention long enough to make any positive intellectual or emotional changes (Ibid). This category is directly related to the characteristic of attracting and holding visitors' attention, just as is the case with all the categories associated with the *Content – Learner Interaction*. It is a characteristic of those categories worth noting because, without visitor motivation to engage with an exhibit in the way that it is intended, or even at all, then none of the learning intended by exhibition designers can occur.

In this section, each of the three categories associated with the *Content – Learner Interaction: Task Activity, Task Path and Task Outcome*, have been discussed. These categories relate to both the *Content* and the *Learner* through the interaction that occurs between those roles. This chapter's discussion on the identified categories relating to those roles and the interaction between them, will be briefly revisited in the next section.

5.5 Conclusion

The relevance of the conceptual framework and the findings of the present study have been discussed in this chapter. First, the conceptual framework was examined and then each of the categories associated with the three implicated concepts of the *pedagogical triangle* were addressed. The *Content* categories, the *Learner* categories and finally, the *Content – Learner Interaction* categories, were used as a basis from which to examine the issues and implications related to the findings situated by the conceptual framework. In the next section, the conclusion of this thesis, the limitations, contributions, and future avenues for research indicated by this study are discussed.

Conclusion

This study has examined, from a *pedagogical perspective*, the *physical context* of the hands-on interactive exhibits in three exhibitions at the *Montreal Science Centre*. The objective of this examination was the identification and categorization of concepts that emerge from the *physical context* of the exhibits. In the first chapter, the research questions that anchor this study were presented and situated within both historical and research contexts. The historical context included the evolution of museums as places of public education, and the development of hands-on interactive exhibits in science centres. The research context focused on the comparison of visitor learning experiences with traditional static and hands-on interactive exhibits, and the effects of exhibition design on those learning experiences.

Several of the studies mentioned in the literature review refer to Falk and Dierking's *Contextual Model of Learning* (2000). In the conceptual framework chapter of this thesis, this model was described and adopted as the conceptual foundation of the study. The model, which contains three contexts, *personal*, *social*, and *physical*, was used with the *physical context* serving as a lens through which to examine hands-on interactive exhibits. Also explained as part of the conceptual framework was the *pedagogical triangle* (Houssaye, 1988; Moore, 1989). This model maps the actors (*teacher*, *learner* and *content*) and the interactions between them for educational processes. It functions in combination with the *Contextual Model of Learning* to form a synthesized framework that was presented in the form of a schematic diagram. Following this synthesized framework, important terms were operationally defined for the purposes of this study, providing a complete picture of the conceptual foundation on which this study is based.

Next, the methodology chapter discussed the collection of data, using written descriptions and photographs, and the analysis of that data. The analysis proceeded in two distinct phases. First, an inductive phase, where emergent concepts were identified from the data and compared across the three exhibitions examined. Then a deductive phase, where the *pedagogical triangle* was associated to those concepts as the highest level in a structure of categories.

In the fourth chapter, the findings were presented. Each of the emergent concepts identified was specified and illustrated using an example, and the structure of categories was specified. The findings were then discussed in the fifth chapter, with the relevance of each identified category specified.

Contributions

In this section the major contributions of the present study will be discussed. Two major contributions will be addressed: first, the creation of a common language and structure with which to identify aspects of hands-on interactive exhibits; and second, a framework for the study of a number of different informal learning situations.

One of the major contributions of this study is a common language and structure for describing and organizing the *pedagogical perspective* of the *physical context* of hands-on interactive exhibits. This structure can enable existing research on specific phenomena related to the *physical context* of exhibits to be located in a continuum. It can also aid in locating and specifying new research, by allowing researchers to identify the phenomena or characteristics of an exhibit they intend to examine. These same implications have significant applications for the

practice of developing exhibits. The structure identified in the findings provides an access point for exhibition designers to understand the place of individual research findings in the broader context of what they can operationalize in an exhibit's design. Similarly the structure breaks down the *physical context* and highlights those places where exhibition designers can influence the learning experiences of visitors, thus aiding in the transfer of research findings to practical applications.

For findings from different studies to be related, there must be a common ground of reference. In the case of this study, the use of two well-recognized models in the conceptual framework helps to provide this common ground. Both Falk and Dierking's (2000) *Contextual Model of Learning* and the *pedagogical triangle* (Houssaye, 1988; Moore, 1989) are models that are widely employed in relation to a broad spectrum of research on learning. Particularly within museum settings, Falk and Dierking's model can be used as a point of reference in the study of aspects of learning experiences. Beyond the relevance of the framework of this study as a point of reference for studies that examine other aspects of museum learning experiences, there also exists a relation to other types of learning experiences. The *Contextual Model of Learning* is intended to be applicable to a multitude of informal learning experiences (Falk and Dierking, 2000) and the *pedagogical triangle* (Houssaye, 1988; Moore, 1989) can be used to describe many learning situations. The application of these two models in the framework of this study makes relation to not just other museum learning experiences but other, particularly informal, learning experiences in general. Especially in the case of objects designed for learning, such as toys or games, there exists the possibility that the framework of this study could ground the examination of other such informal learning situations. As the categories and concepts in the

findings of this study may be relevant to the examination of both museum and other informal learning experiences, this suggests broad implications.

This section has examined two major contributions of the present study: first, a common language and structure for describing hands-on interactive exhibits from a *pedagogical perspective*; and second, the synthesis of a framework suitable for the study of many types of informal learning opportunities. Limitations associated with this study will be examined in the next section.

Limitations

One limitation of this study is that only the *physical context* of hands-on interactive exhibits in three exhibitions at *Montreal Science Centre* was studied. With the use of Falk and Dierking's *physical context* (2000) as a lens, it is immediately evident that only insights visible from that perspective have emerged during the course of this study. This limits the findings to an incomplete picture of the hands-on interactive exhibit learning experience. Particularly in relation to the *Learner* and *Content – Learner Interaction*, the definitions of categories and concepts have often been qualified as those attributes or behaviors solely intended by designers and not those that actually occur. For greater insights into actual visitor behavior, investigations of both the *personal* and *social* contexts would be very valuable. Similarly, though the three exhibitions at *Montreal Science centre* were chosen for the diversity of approaches and content found in their exhibits, not all exhibit possibilities were present. Exhibition design is a field that is constantly changing with new technologies emerging and applications for existing

technologies re-imagined. Due to this, the findings of this study are limited by what was available at the time and location of study. The categories and concepts identified shall need to be regularly updated to reflect changes that occur if they are to be relevant outside this setting.

The choice to only examine the *physical context* of hands-on interactive exhibits in three exhibitions at *Montreal Science Centre* is responsible for the major limitations associated with this study. Further examination of the other contexts and other settings would lead to a much more complete picture than that presented as the findings of this study. These and other avenues for further research will be addressed in the next section.

Further Research

In this section, possible future avenues for further research that follow from this study will be discussed. First, the limitations placed on this study by the focus on the *physical context* of hands-on interactive exhibits, indicate a direct path to pursue. Future research focusing on similar aspects of learning experiences but from the added perspective of either the *personal* or *social* contexts would help a much more complete picture to emerge. This research might well follow a very similar format to the present study, with the identification of emergent concepts, and categorization relating those concepts to the *pedagogical triangle*. If each of Falk and Dierking's three contexts were to be examined in the same exhibits, this would provide an extensive understanding of the learning experiences they engender.

Second, another interesting path to follow would be to apply the same methodology in other science centres. A greater sample of exhibits would allow as yet unseen concepts to emerge, particularly related to different technologies. Furthermore, the structure that emerged during the course of this study could be applied to exhibits in other types of exhibitions. It would be particularly interesting to examine this structure in reference to exhibits in, for example, a natural history museum. Since hands-on interactive exhibits are no longer limited to science centre environments, much could be learned from comparing this structure developed from the exhibits of a science centre to those in other types of institutions.

There exists a multitude of unanswered inquiry questions on the dynamics of hands-on interactive exhibits and learning experiences. This study has identified and categorized, from a *pedagogical perspective*, the concepts that emerge from the *physical context* of the hands-on interactive exhibits in three exhibitions at the *Montreal Science Centre*. It has opened the door to a number of future avenues for researchers, including examining exhibits in a greater variety of museums and investigating the *personal* and *social* contexts. It is hoped that these and other avenues are explored and that the resulting knowledge helps exhibition designers to create improved and more-fulfilling learning experiences in museums.

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Appendix A

Montreal Science Centre Profile Web Page

MONTRÉAL SCIENCE CENTRE - THE CENTRE - PROFILE

http://www.centredeciencesdelmontreal.com/en/centre/centre_profil.htm



RETOUR À L'ACCUEIL INFO IMAX® ACTIVITIES TEACHERS

HOME > THE CENTRE > PROFILE

OUR MISSION

The mission of the Montréal Science Centre is to help visitors of all ages acquire an understanding of science and technology for use in building their future.



Who is the Montréal Science Centre for?

For anyone interested in science and technology and who wants to make it a dynamic and interactive experience.

- For the general public : especially for families-to stimulate their interest in science and technology and raise their awareness of its importance in our society; and for young people, to stimulate their curiosity, arouse a passion for knowledge, and develop a taste for careers in science.
- For the education system: for school groups, within whose ranks are the future of our research and business communities, and for the educators charged with transmitting knowledge.
- For businesses : whose participation ensures the dissemination of local know-how.

The objectives of the Montréal Science Centre

- Develop the culture of science and technology.
- Develop a taste for careers in science and technology.
- Collaborate in training educators.
- Promote the knowledge and know-how of local businesses.

Content that's accessible to all

The Science Centre's amazing, fun, and surprising exhibitions allow visitors to

- THE CENTRE
- PROFILE
- FOUNDATION
- PARTNERS
- THE MAGAZINE
- HALL RENTALS
- FILM SHOOTINGS
- PRESS ROOM
- LEGAL NOTICES



FRANÇAIS

PROFILE

- Mission
- History



Our Quality Commitment [PDF, 65 Kb]

Our Environmental Commitment [PDF, 98 Kb]

Hands-on Interactive Museum Exhibits 114

MONTRÉAL SCIENCE CENTRE - THE CENTRE - PROFIL F

http://www.centredessciencesdemontreal.com/en/centre/centre_profil.htm

explore, learn, and understand through a variety of interactive means. The scientific exhibitions have been designed to :

- make the science and technology that shape our daily lives more accessible,
- provide visitors with a direct and amusing connection to basic scientific concepts and techniques,
- develop an understanding of the impact of scientific and technological applications on our daily lives and on society as a whole.

The Montréal Science Centre highlights and explains recent Canadian innovations and inventions both within the exhibition halls and in its public areas to show them off and make visitors more aware of the know-how of our local industries.

In an effort to rejuvenate, support, and stimulate the teaching of science, the Science Centre, in collaboration with the ministère de l'Éducation du Québec, has created education programs for primary and secondary school students. It has also developed a careers-in-science program, with the goal of making current information about careers in science and technology available to young people.

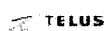
A team of consultants in the fields of education, communications, science and technology assists the programming team in developing its exhibition programs and its educational and cultural activities.



The Montréal Science Centre is a member of the Board of Montreal Museum Directors. To learn more about the activities and on the mission of the organization, visit its website: <http://www.museesmontreal.org>

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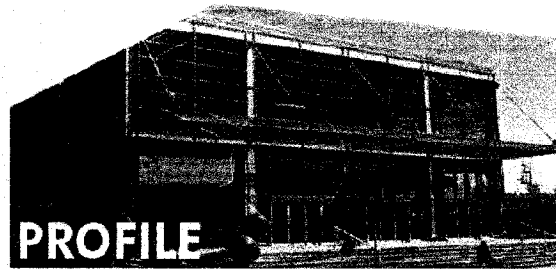
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Montreal Science Centre History Web Page

MONTREAL SCIENCE CENTRE THE CENTRE PROFILE

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PROFIL EN FRANÇAIS INFO IMAX® ACTIVITIES **Arts** TEACHERS FRAMMENT

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THE CENTRE

- PROFILE
- FOUNDATION
- PARTNERS
- THE MAGAZINE
- HALL RENTALS
- FILM SHOOTINGS
- PRESS ROOM
- LEGAL NOTICES



A BRIEF HISTORY

1987 :
The first EXPOTEC (Interactive science exhibition) opens in Hangar 7 on the King-Edward Pier.

1987 to 1995 :
Nine EXPOTEC exhibitions held in Hangar 7.

- EXPOTEC themes :*
- 1987 :** Centennial of engineering
 - 1988 :** Health
 - 1989 :** Communications
 - 1990 :** Sports
 - 1991 :** Human evolution
 - 1992 :** Music
 - 1993 :** The invention craze
 - 1994 :** The magic of electricity
 - 1995 :** A celebration of chemistry

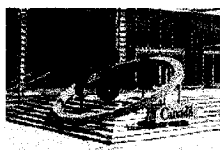
1998 :
Construction begins on the ISci centre on the King-Edward Pier.



6 mai 2000 :
ISci centre opens.

PROFILE

- Mission
- History



2002 :
The centre gets a new name: the Montréal Science Centre

AWARDS

2000 :
Prix Möbius Québec-Canada for the 16 multimedia games of the permanent exhibitions.

2001 :
Attraction touristique awarded by Tourisme Montréal.
Quebec tourism Grand Prize : *Attraction touristique* (100,000+ visitors) awarded by Tourisme Québec.




2002 :
Coup d'éclat awarded by the SATQ for the television advertisement produced with Jean-René Dufort.

2005:



(SMQ) The Montréal Science Centre has been honoured with an Excellence Award 2004-2005 for its exhibition *A Journey of a Lifetime*, now showing at the Musée de la Civilisation in Québec City.

THE CENTRE INFO IMAX® ACTIVITIES  TEACHERS 

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Montreal Science Centre Eureka! Web Page

MONTREAL SCIENCE CENTRE - ACTIVITIES - EUREKA!

http://www.centre-des-sciences-demontreal.com/en/activites/activites_eurek...



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ACTIVITIES

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- DYNAMO'S LAIR
- EUREKA!**
- TECHNOCTY
- SPECIAL EVENTS
- INTERACTIVE MOVIE GAME
- 36 SOLUTIONS
- ARCHIVES

Themes:

- Health: food and cutting-edge technology in health sciences
- Matter: the physical properties of materials
- Habitat: adaptation to the environment
- Waves: the nature and properties of sound and light waves
- Forces: unusual physical phenomena



EUREKA!

- Schedules
- Rates and Packages



DID YOU KNOW ...

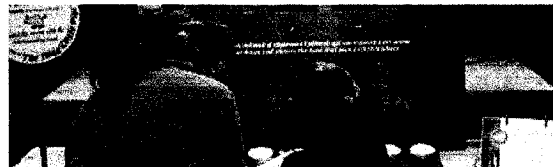
that contrary to what you might think, if a volcano's lava were blue, it would be even hotter! In fact, the colour corresponds to light waves that dissipate as heat, and blue dissipates more heat than red.

Through interactive games, come learn how physical phenomena affect our everyday lives. 41 activities are available to visitors to test their knowledge and learn more about the world around them; for example :

- Make a diagnosis by looking at MRI (magnetic resonance imagery) images.
- Test different materials' reaction to torsion and evaluate their resistance.
- Find out why the orientation of your home is important.
- Discover the transmission properties of parabolic dishes.
- Line up a telecommunications satellite over Montréal.

Quiz

[Click here!](#)



Montreal Science Centre X-Treme Rotation Web Page

MONTRÉAL SCIENCE CENTRE - ACTIVITIES - X-TREME ROTATION http://www.centredessciencesdemontreal.com/en/activites/activites_rotati...





CENTRE
DES SCIENCES
DE MONTRÉAL
Cassidy

THE CENTRE INFO IMAX®   TEACHERS FRANÇAIS

HOME > ACTIVITIES > X-TREME ROTATION

ACTIVITIES
ICE AGE MAMMALS
X-TREME ROTATION
DYNAMO'S LAIR
EUREKA!
TECHNOCITY
SPECIAL EVENTS
INTERACTIVE MOVIE GAME
36 SOLUTIONS
ARCHIVES

X-Treme Rotation
Until March 19, 2006

THE EXHIBITION IS NOW OVER!

Did you know that just about everything in the universe is based on the **principles of rotation?**

If you think that's an exaggeration, turn your head (there's one rotation already!) and take a look around you.



Your **bike** in the hallway, the **lawnmower** in the yard, the pair of **scissors** on the counter, even the **office chair** you're sitting on right now—they all employ rotation. And that's not counting **your body**, which uses one principle of rotation or another just about every time it moves.

Intrigued? Curious? Check out the new exhibition at the Montréal Science Centre, **X-treme Rotation**.

What's X-treme Rotation like?
It's a **500 m²** room divided into five zones:

► **Robots... manifold rotation**

As you enter, you encounter the **Rotoscopic Machines**, a work by Bill Vorn.

Light and sound enhance the ambience of this intriguing space, where visitors can **interact with one or several of the five robots** suspended from the ceiling. Built from pneumatic valves, sensors and video cameras, the robots carry out rotational movements as visitors approach, performing a strange and **surprising choreography** that blurs the boundaries between human and machine.



Rotoscopic Machines combines **robotics, mechanics, electronics and computer technology** to create a bizarre universe indeed!

SEE ALSO:
Rotation online GAMES
Sk8 Crazy! event



Final results of the competitions and photos!





* Objects... high-performance rotation

Five key items illustrate the principles of rotation used in almost everything we manufacture: the **wheel**, the **gear**, the **screw**, the **lever**, and the **gyroscope**.

The principles in this zone are explained through different **activities** (roll the discs down a slope to see which descends faster) and through **technological applications** (assemble the gears to turn the disc).



* The body... all-around rotation

Our skeleton is a world-class rotator.

Slip on the **movement-sensor vest** and watch your joints move on the monitor.

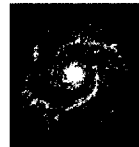
On the big screen, **Johnny Skywalker**, the *b-boy*, demonstrates his body's ability to rotate, and a spinning platform nearby lets you try his techniques!



* The Universe... infinite rotation

Rotation occurs on **very large scales**, such as galaxies, and on **very tiny scales**, such as cells. Watch the movies shown side-by-side on two large screens; you'll be amazed by the similarities!

Inertia, **centripetal force** and **centrifugal force** are principles of rotation that act as the "glue" holding our universe together. Without rotation, the Earth would not have tides, days would last a year—and it gets worse! By the way, have you ever heard **the sound of the stars**? Come... listen...



* Creation... rotation galore

At the end of your journey is **the studio**, a space for **play and creativity**.

This is where you have fun with rotation. Play with a **small tornado**, deforming and disrupting it; **build a super top** using the principles explained in the exhibition, then **test your prototype** against others.

You can even use templates to **develop your own computer-based choreography**, sign your creation and put it up on the big screen to get the full effect!

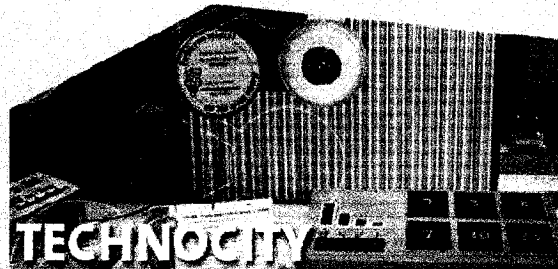


A visit to **X-treme Rotation** is an adventure where you will **learn, play, touch, test and understand**—knowledge and fun all rolled into one— and the world will never seem the same afterwards. Guaranteed!

Montreal Science Centre Technocity Web Page

MONTREAL SCIENCE CENTRE - ACTIVITIES - TECHNOCITY

http://www.centredesciencesexplemontreal.com/en/activites/activites_techn...



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ACTIVITIES

- ICE AGE MAMMALS
- DYNAMO'S LAIR
- EUREKA!
- TECHNOCITY
- SPECIAL EVENTS
- INTERACTIVE MOVIE GAME
- 36 SOLUTIONS
- ARCHIVES

Themes:

- Computers and robotics: computer language and robot programming
- Design and development: creation of new products
- Communication and information: from binary to digital
- Energy and resources: exploitation and management



TECHNOCITY

- Schedules
- Rates and Packages



DID YOU KNOW ...

that there are over 100 varieties of artificial strawberry flavour: green strawberry, ripe strawberry, field strawberry, garden strawberry, candied strawberry... In fact, our taste buds often have trouble telling the difference between natural flavour and artificial flavour!

36 activities to understand the effect of technology on the world around us:

- Examine masterpieces of miniaturization under a microscope.
- Design the most efficient bike you can.
- Find out how to decode an electronic message.
- Analyze data from satellite photos.

Quiz

Click here !



THE CENTRE INFO IMAX® ACTIVITIES **Adts** TEACHERS ⓘ

Appendix B

Montréal, le 20 janvier 2006

À qui de droit,

C'est avec plaisir que le Centre des sciences de Montréal autorise Thomas Hillman, étudiant à la maîtrise en éducation à l'Université d'Ottawa, à faire une étude dans nos salles d'exposition.

Par ses observations et son analyse, Monsieur Hillman tentera de mieux comprendre comment les interactifs d'un centre de sciences peuvent contribuer à l'apprentissage informel. Cette meilleure connaissance des interactifs nous permettra, à notre tour, d'élaborer des produits qui sont plus efficaces et qui rejoignent davantage les attentes des visiteurs.

Le Centre des sciences de Montréal remercie Monsieur Hillman de nous avoir choisi comme terrain d'étude et nous lui souhaitons le plus grand succès dans ses recherches.


Louise Julie Bertrand
Chef du développement et de la réalisation
Direction des expositions



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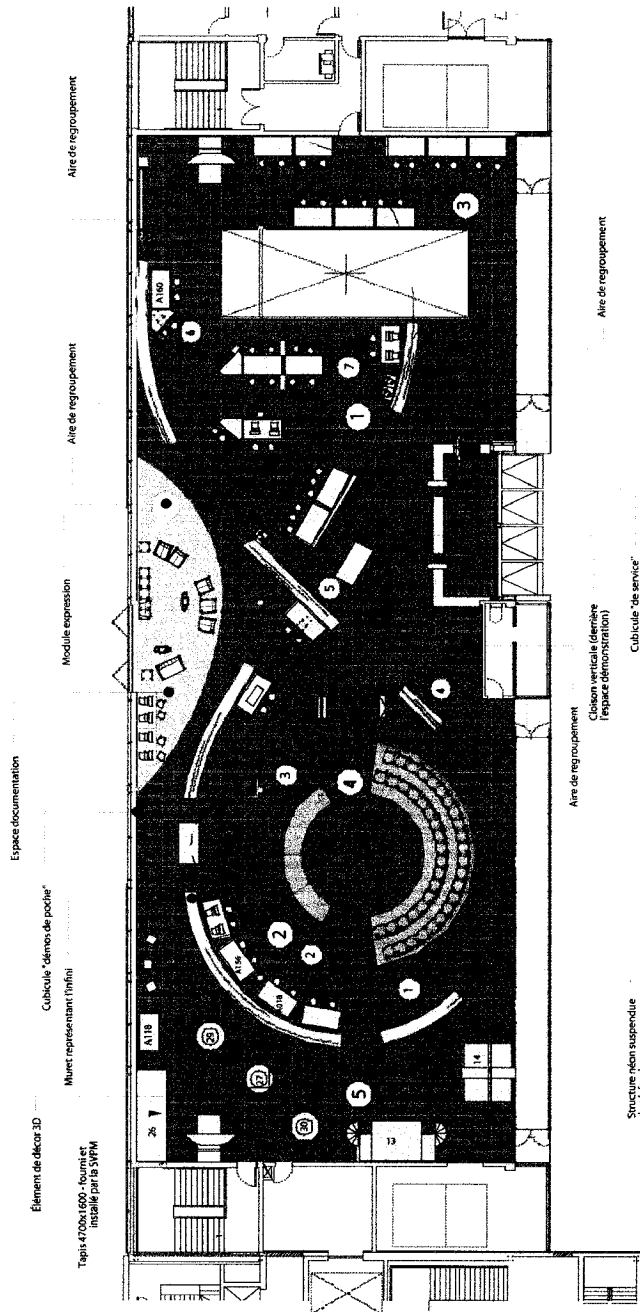
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MontrealScienceCentre.com

Appendix C

Eureka! Floor Plan



1 La santé

- A001 État de vos dents, votre santé ?
- A003 Aliments sains ou saines ?
- A160 Qu'est-ce qu'on mange ?
- A033 Corps à corps
- A036 L'homme visible sous rayons X
- A036a L'homme visible sous rayons X - console
- A036d L'homme visible grâce à l'écran
- A155 La vie qui bat (+ panneau contextuel)
- S015 Stéthoscope électronique
- A042b Douges adroits (+ panneau contextuel)
- A045 Générique 101
- A046 Jeu de genes et de hasard
- A067 Thérapie géniale (+ panneau contextuel)
- S018 Carte des gènes

2 L'habitat

- A032 Une place au soleil
- A156 Maisons candides
- A027 Terrain de Terrens
- A024 Les acariens attaquent!
- A018 (+ panneau contextuel)
- A018a J'ai vu un cocon, j'en ai un
- 3 La matière
- A064e Bons rebonds
- A064f Le roseau d'aluminium
- A064g Firmament
- A064h Blocs surprises
- A064i AaaaOooohHumm
- A064o Le bord tuyaut
- A064w Station de pompage

4 Les ondes

- A154 L'harmonie, c'est toujours ouïe
- A116 Les soupapes parlantes
- 7 Pender ou gagner des poids (1/2)
- 9 Tour d'avion
- 10 La multiplication des objets

5 Les forces

- 11 Les ports suspendus
- A117 Le pont de la Terre
- 14 A partir pas l'équilibre
- 23 L'École des filins
- 28 Toujours plus Haut !
- 29 Les ponts de bois
- 30 Le cloit des daffs

Plan d'aménagement - 1/200

Le groupe DES - 25 juillet 2002

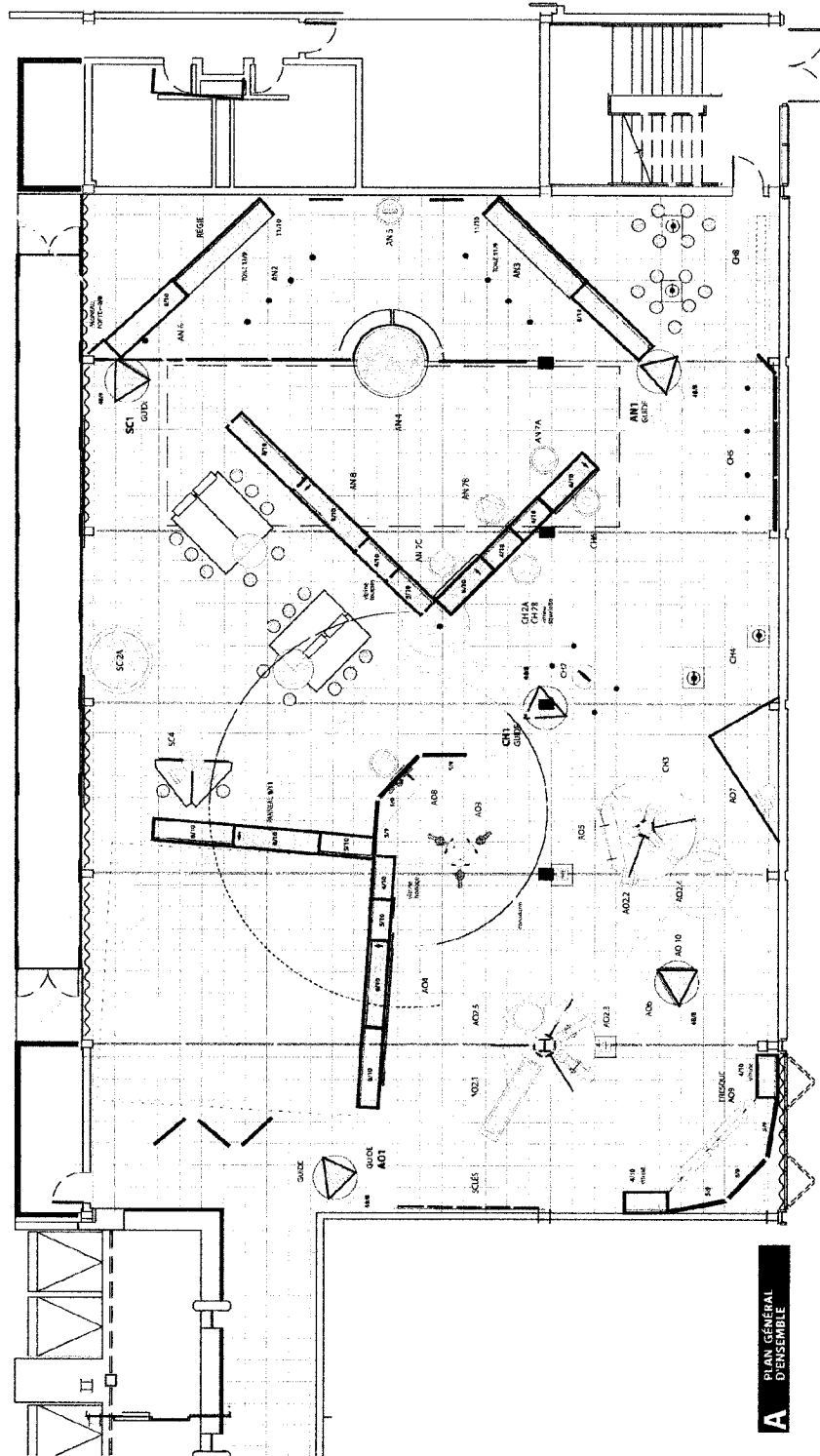
LUPUSKI

Centre des services de Montréal

Réaménagement

3 dans 2

X-Treme Rotation Floor Plan



Appendix D

Categorization Process Examples

