DESIGN INTENTIONS AND OUTCOMES IN MUSEUMS

by

Kevin Muise
Bachelor of Design, York University 2003

THESIS (PROJECT/RESEARCH PROJECT/DISSERTATION)
SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the
School of Interactive Arts and Technology

© Kevin Muise 2010

SIMON FRASER UNIVERSITY

Spring 2010

APPROVAL

Name: **Kevin Bruce Delmer Muise**

Degree: **Master of Arts**

Title of Thesis: **Design Intentions and Outcomes in Museums**

Examining Committee:

Chair: _____

Marek Hatala
Associate Professor
School of Interactive Arts and Technology

_____

Ron Wakkary
Senior Supervisor
Associate Professor
School of Interactive Arts and Technology

_____

Alissa Antle
Supervisor
Assistant Professor
School of Interactive Arts and Technology

_____

Jim Budd
External Examiner
Associate Professor
Faculty of Design + Dynamic Media
Emily Carr University of Art + Design

Date Defended/Approved: March 11, 2010

Declaration of
Partial Copyright Licence

The author, whose copyright is declared on the title page of this work, has granted to Simon Fraser University the right to lend this thesis, project or extended essay to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users.

The author has further granted permission to Simon Fraser University to keep or make a digital copy for use in its circulating collection (currently available to the public at the "Institutional Repository" link of the SFU Library website <www.lib.sfu.ca> at: <http://ir.lib.sfu.ca/handle/1892/112>) and, without changing the content, to translate the thesis/project or extended essays, if technically possible, to any medium or format for the purpose of preservation of the digital work.

The author has further agreed that permission for multiple copying of this work for scholarly purposes may be granted by either the author or the Dean of Graduate Studies.

It is understood that copying or publication of this work for financial gain shall not be allowed without the author's written permission.

Permission for public performance, or limited permission for private scholarly use, of any multimedia materials forming part of this work, may have been granted by the author. This information may be found on the separately catalogued multimedia material and in the signed Partial Copyright Licence.

While licensing SFU to permit the above uses, the author retains copyright in the thesis, project or extended essays, including the right to change the work for subsequent purposes, including editing and publishing the work in whole or in part, and licensing other parties, as the author may desire.

The original Partial Copyright Licence attesting to these terms, and signed by this author, may be found in the original bound copy of this work, retained in the Simon Fraser University Archive.

Simon Fraser University Library
Burnaby, BC, Canada

STATEMENT OF
ETHICS APPROVAL

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

(a) Human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

(b) Advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

(c) as a co-investigator, collaborator or research assistant in a research project approved in advance,

or

(d) as a member of a course approved in advance for minimal risk human research, by the Office of Research Ethics.

A copy of the approval letter has been filed at the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Simon Fraser University
Burnaby, BC, Canada

Last update: Spring 2010

ABSTRACT

This study explores the value of constructivist theory in the field of interaction design in museums by investigating the relationship of constructivist design intentions to their outcomes. As the design of technologies has shifted from instrumental aspects of interactive systems to the design of experience, there has become an increasing need to develop frameworks and evaluation techniques grounded in theory to support this change. Current approaches to understanding the user experience are underdeveloped and this study of intentions and outcomes aims to address this shortcoming through an exploratory multiple-case study approach. Museums were selected as a context to investigate these relationships since designers often take a constructivist approach in the development of interactive technology towards the design of experiences. The findings of this study point to an emerging constructivist framework by providing a series of themes, guidelines and evaluation techniques based on constructivist principles.

ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

The use of interactive technologies has become ubiquitous in our everyday lives. Where once only used by people with technical backgrounds to accomplish work-related tasks, interactive systems have moved outside of the professional environment and into the hands and homes of millions of people. Interactive technologies are now used to communicate with others, as a source of entertainment, as a tool for learning, as well as a range of other activities that help fulfil people's personal needs.

The shift in activities surrounding the use of interactive technologies has brought about a change in approach by those engaged in the field of human computer interaction (HCI). Initially the development of interactive systems focused mainly on issues of efficiency, but as systems became more pronounced in society, efforts expanded to involve user-centric approaches to provide those with non-technical knowledge with tools that could be more readily learned and used. These user-centric approaches involved measures of task completion time, error rate, along with gathering subjective responses from users to understand issues related to satisfaction. This approach continues to dominate the field of human computer design and is indeed useful in addressing well-defined tasks, such as withdrawing money from a bank machine. However, as designers of interactive systems seek to integrate technology into people's everyday experiences, new approaches have become necessary in the design and

evaluation of interactive systems to address activities that are deeply personal and less defined. The interest in developing technologies that engage users through the provision of experiential value on a personal level has sparked new approaches concerned with user experience. As research on the subject of user experience has grown in recent years, qualitative approaches have emerged to evaluate affective, personal, aesthetic, and other subjective factors to inform design decisions.

The increased focus on the user experience has created a need to adopt a theoretical model to assist the development of design frameworks and evaluation techniques. One theory that applies to the understanding of the individual and the engagement in designed spaces – issues that are central to the design of experiences – is constructivism.

1.1 Focus and Aims of the Study

The aim of this study is to understand how constructivism may serve as a theoretical model to address shortcomings in existing research surrounding the user experience. Though frameworks to understand experience currently exist, there is a lack of evaluative techniques to support existing efforts, which make it difficult to understand the outcome of certain design moves. This study attempts to address this shortcoming through the exploration of design goals, expressed as intentions, and their outcomes as experienced by users, within a constructivist perspective.

Museums were selected as a context to observe the relation of intentions and outcomes, as they provide a rich context to observe people interacting with each other and interactive technologies in ways that are non-task orientated. Museum designers are not only concerned with technologies and space, but also with the creation of experiences, which are often founded on constructivist principles. Furthermore, museums offer existing validated evaluation techniques that can be adapted for the purposes of this study and a number of these are considered constructivist in nature.

Having selected museums as a context for this study and having provided the overarching aim of this study, the research questions will now be presented. The first question that will be addressed in this study is: *How are constructivist intentions expressed by designers?* The answer to this question will provide future designers with an understanding of the relationship of constructivist principles – which are often broad and lack specificity – to intentions that can be used in practice. Currently there is a lack of understanding of how to use constructivism to design interactive technologies. This study will attempt to address this shortcoming through an exploration of that area.

The second research question within this study is: *What is the relationship between design intentions and their outcomes*? This question seeks to understand how design intentions, described by the museum designers, relate to the outcomes experienced by museum visitors. In doing so, the study addresses the need to understand how design actions, described as intentions, impact the experience of the product. The result of this question can then be applied to the

construction of a constructivist interaction design framework that provides a set of themes, guidelines, and their corresponding effect on the visitor's experience.

1.3 Approach

The study takes a qualitative approach to investigate the aforementioned research questions. Qualitative research provides a rich, holistic, description that focuses on process, meaning, and understanding (Merriam 1998). The qualitative method used in this study takes the form of exploratory multiple case studies, as they are useful in describing processes, activities, and events with considerable detail (Creswell 1994). Additionally, case studies rely on qualitative analysis and sometimes, quantitative methods, to connect cause and effect – an issue that is central to this research.

A multiple-case approach was chosen instead of a single case in order to better understand the phenomenon in question and to provide further reliability to the findings. The two cases include an interactive museum guide installed at the Surrey Museum, and an exhibit that focuses on how the body works, located at Science World in Vancouver.

Within each case, designers who were central to the design of the interactives were interviewed using a semi-structured protocol to gather information on design intentions. The interviews were later coded to uncover overarching themes that help to explain the phenomenon. Following the interviews, participant observation sessions where conducted with a number of family groups using an existing constructivist evaluation protocol. The data

collected from these sessions was tabulated for frequencies and qualitative statements were extracted. The information gathered from the observation sessions provided evidence to understand the visitor experience. After a two-to-four week period, the participants from the observation sessions conducted a self-administered interview, which provided further evidence regarding their experience.

Following the collection of data, design intentions were compared to the findings collected on the family visits to understand their relationships within each case. A cross-case analysis was then conducted to understand the similarities and differences of the relationship of design intentions to the outcomes experienced by the participants.

1.4 Research Contributions

This research hopes to contribute to a number of areas within interaction design. It addresses issues within the area of interaction design in general, making it useful to current-day designers, while also addressing issues within interaction design research, which speak to more long term implications.

First, the study contributes directly to an understanding of the application of constructivism to interaction design problems, especially those within museums. More so, the study attempts to elucidate how constructivist principles are interpreted to form design intentions, an aspect that is currently lacking in existing research.

An additional contribution to interaction design is the implications towards the emerging field of experience design. Current shortcomings within experience design research include the lack of approaches grounded in theory and difficulties pertaining to the evaluation of an individual's experience using interactive technologies. This study aims to address these shortcomings by proposing constructivism as a useful alternative.

With regards to contributions to design research, this study provides valuable insights to the study of designers and design itself by investigating design knowledge in people, processes, and the products they create. The methodology used in this study focuses on all three sources of design knowledge, which may serve to provide methodological insights on how to explore the relationship between design intention and outcomes.

As a final contribution, this study hopes to excite a discussion within design research on the epistemological approaches used to evaluate design artifacts and positions constructivism as a budding design epistemology.

1.5 Overview

The discussion and exploration of the study's research questions are divided into eight chapters. Each chapter is outlined below to provide the reader with an overview of this thesis document.

Chapter 2: Background

This chapter provides the theoretical background to my research study, while also presenting related research. The chapter discusses the role of design

goals and evaluation in the design process and positions constructivism within the process of goal formation. An overview of design methods and existing research in the area of user experience are also discussed in order to frame the application of constructivist theory in the context of interaction design.

Chapter 3: Museums as Investigative Context

This chapter aims to provide the reasoning for selecting museums as a context to study the use of constructivist goals and their outcomes. An overview of museum exhibit design is presented in this chapter to describe their focus on the design of artifacts, interactives, and experience. Additionally, a description of the use of constructivism in museums is presented, along with associated evaluation techniques that are beneficial to this study's endeavours.

Chapter 4: Methodology

This chapter describes in detail the methodological approach taken to study the relationship between design goals and their outcomes. It presents the research questions that are central to this study, along with discussing the research design and data processing methods used.

Chapter 5: Analysis of Cases

This chapter presents a description of the two cases that were selected for this study. The case involving Kurio at the Surrey museum is presented first, followed by the Science World case. Each case involves the analysis of two units of study (designer and family groups). The data from these two units of analysis are then used to provide a comparison of design intentions to outcomes.

Chapter 6: Findings

This chapter relates the findings from the two cases to the research questions presented in chapter four. The descriptions of design intentions are presented as themes and the data collected from each case is compared in order to address the research question relating to the understanding of constructivist design intentions. The findings on the relation of design intentions to outcomes from each case are then compared to address the second research question of this study.

Chapter 7: Discussion

This chapter's aim is to discuss the findings presented in chapter six and position them within the larger field of interaction design, which was described in chapter two. The research study's contributions are discussed in terms of their implications for design practice, followed by a discussion on the implications for design research. The chapter concludes with a description of the research study's limitations.

Chapter 8: Conclusion

This chapter concludes the research study by presenting a summary of the investigation and suggests areas for further research.

CHAPTER 2: BACKGROUND

This chapter provides the theoretical background to my research study; it begins with a discussion on the relation of design goals to evaluation (section 2.1), then positions the process of goal formation as being influenced by various factors, including a designer's beliefs and values (section 2.2). Constructivism is proposed as a direction to explore design goals in the field of interaction design, and an overview of the theory is provided in section 2.3. Following this, an overview of interaction design evaluation methodologies is presented in section 2.4. The chapter concludes with a summary of the weaknesses in the previous research, and a discussion of approaches to address those issues presented (section 2.5).

2.1: Design Goals

Design often begins with an awareness of a need, or dissatisfaction, with a current state, or ideas pertaining to future needs (Bijl 1987). In this light, design is positioned as a process that involves goals, which is in accordance with Archer's description of design as a "goal-driven" activity (1984). Herbert Simon also defines design in a similar manner explaining that, "design is concerned with how things ought to be, with devising artefacts to attain goals" (1996). Given the importance of goals in the design process, it is useful to define what is meant by "design goals". Pena in his book, *Problem Seeking*, describes design goals as being comprised of four aspects: form, function, economy, and time (1969).

Though this description is useful to understand aspects of design goals, it avoids

providing a description for the term itself. Similarly, Scrivener et al. also avoid

presenting a definition when they describe design goals as being formed by

perceived needs of a product and necessary to characterize a project's

objectives (2002). In both these previous attempts at defining design goals, the

authors either describe how they are formed or what they are comprised of. In

order to expand and define the definition more clearly, this study sees design

goals as *a desired outcome from the design process*. The word "outcome"

signifies either a physical artifact or experience and, "design process" is

described as the variety of tasks and decisions which the designer performs to

arrive at the outcome.

2.1.2: Importance of Design Goals

As previously discussed, design is goal-driven, meaning that the initial

goals of a designer help to direct the decisions that are made throughout the

entire process. Scrivener et al. make this more clear when they state that goals

help in the characterization of a product's objectives, and that objectives help to

form requirements that act as guidelines in the creation of a design (2002). Not

only are goals important in guiding the design process, they also play an

important role in the evaluation of the designed outcome.

In his book on design thinking, Rowe describes that "outcomes are

evaluated in terms of goals", and states that, "a reasonable correspondence must

be struck between an expression of an outcome and an expression of a goal"

(Rowe 1987). The author is suggesting here that in creating an artifact, the

designer sets goals, and that the outcome of the design process should not only relate to these goals, but also should be evaluated within the context of these initial goals. In accordance with this perspective, Scrivener et al. explain that design goals and evaluation are not just related but that evaluation expresses "whether, why, and to what extent the anticipated effect of the proposed solution is positive or negative" (2002). The terms "positive" and "negative" are used to signify whether the solution is successful or not in relation to the initial goals. This concept is mirrored within the field of human computer interaction (HCI), where design goals aid in establishing criteria to be applied in the evaluation and usability testing phase of the design process (Jacko 2003). Furthermore, this criteria formed through the establishment of design goals is a means to evaluate not only solutions, but also a way to judge the value or quality of them.

2.2: Design Problems and Goals

Having established what design goals are and their importance within the design process, this section will discuss design goals in relation to design problems. The nature of design problems is a topic of much discussion within the field of design research and a brief overview will be described before discussing how goals emerge from problems.

2.2.1: Understanding Design Problems

Research in the area of design methodology has treated the issue of design problems in two fundamentally different ways, which are based in two differing paradigms; Simon's rational problem solving, based in a positivist

epistemology; and Schon's reflective practice that is grounded in phenomenology (Dorst, 2004).

From Simon's perspective, design is seen as a rational problem-solving activity, which begins by defining a problem on how an artifact should function, enumerating solutions, and then using pre-defined methods for selecting the optimal solution from among the alternatives (Krippendorff 2007). In positioning design problems in such a light, Simon's approach has been met with scepticism and Simon himself admitted that not all problems could be defined, issuing the term "ill-defined" to explain such scenarios (Simon 1984). Others too have written on the topic, using terms such as "ill-structured" (Reitman 1964) and "wicked" (Rittel and Webber 1984) to explain the open-endedness of design problems.

From a different paradigm of design methodology emerges Donald Schon, who introduces the notion of reflective practice. Reflective practice involves the designer thoughtfully considering his design actions, or "moves", using implicit knowledge of the design situation (Schon 1983). Schon rejects the notion that there is a definable design problem to start with and insists that Simon's approach can only be applied to well-formed problems. Instead, the author explains that design problems emerge from a reflective-conversation between the designer and the situation (Dorst 2004). In order to formulate a design problem, the designer frames the situation through setting its boundaries, selecting particular aspects and placing on them a viewpoint that guides the decision-making process (Schon 1988). In comparing Schon's perspective to Simon's it can be understood that Schon captures the nature of design problems

more accurately, while also humanizing the design process through re-affirming the role of the designer.

2.2.2: From Design Problem to Design Goal

Emerging from Schon's perspective on design problems and the importance of the designer's use of implicit knowledge is Harfield's categorization of design problems. The author describes three categories that provide insight into the process of goal formation: (1) initial problem requirements, (2) problem as given, and (3) problem as design goal (Harfield 2007).

Initial problem requirements is the problem that is presented to the designer by an external source, such as a client, which Harfield explains as lying "outside" the designer. This brief is comprised of a set of requirements that in combination make up the problem that the designer is expected to solve (Blyth and Worthington, 2000). The brief can be thought of as "given" as it is provided by the client, and is often regarded as being factual and pragmatic, which can lead it to being regarded as an objective document (Harfield, 2004).

Harfield's second category, the *problem as given*, outlines how the initial brief provided by an agent outside of the designer, will invariably be augmented by the designer with additional information based on the designer's expertise (Harfield 2004). Through a detailed study of designers in practice, Chayutsahkij has also demonstrated this notion, showing that goal formation in design studios emerge from the balancing of three forces: business, technology, and user-needs (2002). This balancing of forces can be treated as a dialogue between the

designer and the design problem, from which a set of augmented requirements

emerges. Harfield contends that many practitioners and theorists believe that it is

from the latter set of requirements that design goals emerge. Further, despite

these goals being mediated, they are often viewed as not being influenced by

any personal preference on the part of the designer. The designer is often

viewed as being objective in the selection of goals based on the initial criteria

provided and the designer's expertise (Harfield 2004).

The third category, the *problem-as-design-goal*, is explained as being the

problem that designers actually solve. Harfield explains that the *problem-as-

given* is what designers may use as a starting point, but that the designer adds

another set of criteria that did not come from the brief. This additional information

is what the author terms as "designerliness", which is not merely comprised of

aesthetic choice, but also an ideological attitude within design and design

thinking (Harfield 2004). The author explains that a practitioner may create

several possible solutions to a problem, all of which satisfy the problem-as-given,

however what separates these solutions from each other is how well they satisfy

the "designerliness" criteria that the practitioner had introduced into the

requirement brief. It is this "designerliness" paired with the *problem-as-given* that

forms the *problem-as-design-goal*. Additionally, Harfield rejects the idea that the

designer is objective because problems are approached with an initial set of

assumptions, beliefs and prejudices that affect the way the designer engages in

the process of design (2004). Finally, the author contends that designers'

structure goals through the use of implicit knowledge to create frames for future

design moves, similar to what Schon describes, while they also influence the design outcome through their own personal preferences.

The perspective presented by Harfield is in accordance with Nigel Cross' perspective of goal formation, particularly with regards to the notion of "first principles" (2007). Through his research on designers Cross discovered that many designers frame a problem in a personal way, then proceed to design by "first principles". Cross employs the term "first principles" to define the initial goals that guide designers in the process of design which emerge from the practitioner's personal preferences (2007). Personal preferences may be formed in various ways, however Harfield contends that these preferences are grounded in a designer's ideological and theoretical commitments, which "assist, lead, and control the designer" (2004). Interestingly, the theoretical commitments of designers are often taken for granted and remain under-analyzed despite their effect upon both the design process and the resulting outcome.

2.2.3: Summary

This section focused on the process by which design problems lead to the creation of design goals. First, it positioned the designer as having a central, subjective role in synthesizing the design problem through referring to Schon's work in design research. Secondly, this section described the process by which designers establish design goals from a variety of sources, including the design brief, implicit knowledge, along with their own personal beliefs. Finally, this section demonstrated the importance of a designer's theoretical commitments in the formation of design goals, and in doing so, it highlighted the importance of

15

investigating the ideological groundings of designers along with how they manifest themselves as design intentions.

2.3: A Constructivist Approach

This section positions constructivist theory as one approach to explore the theoretical commitments of designers and provides evidence that interaction designers apply aspects of constructivist theory when setting goals.

2.3.1: Constructivist Theory

Constructivism is a psychological theory about knowledge and learning that arose through the work of Jean Piaget, Lev Vygotsky, and Jerome Bruner, among others (Fostnot and Perry 2005). Despite the various manifestations of constructivism, they all share in the rejection of the positivist notion that a correspondence between knowledge and reality is possible (Chiari et al 1993). Of the different constructivist approaches, both personal constructivism and social constructivism are most prominent (Cobb 1994). Cobb argues that the two approaches serve to compliment each other and states that knowledge is both constructed through social interaction and in the individual's mind (1994). The author's perspective serves as a useful approach to discuss constructivism within this study.

In order to provide a coherent understanding of the theory, Vrasidas has developed a set of five philosophical and epistemological assumptions that are held by constructivists, listed below:

1. A real world exists that acts as a boundary for what an individual can experience. Despite this, reality exists in the mind of the individual, necessitating multiple realities – one for each individual.
2. The structure of reality is created in the mind through interacting with the world. The structuring of reality occurs through the use of symbols.
3. The mind creates symbols by perceiving and interpreting the world.
4. Human thought is developed through perception, sensory experiences, and social interaction.
5. Meaning occurs through an interpretive process that is dependent upon an individual's previous experiences and understandings (Vrasidas 2000).

Beyond the principles listed above, constructivism can be understood as a process by which one is engaged in meaning making (Fosnot 2005). In this manner, knowledge is not an accurate copy of reality, but rather a "mapping of actions and conceptual operations that have become useful through an individual's experience" (Von Glasersfield 2005).

2.3.1.1: Nature of Constructivist Learning

Constructivist theory is widely used to explain the nature of learning. In particular, educationalists have adopted constructivist theory and helped to formalize it for use within traditional educational settings, such as the classroom.

Constructivism acknowledges the uniqueness of the individual, both in terms of their needs and backgrounds (Wertsch 1997). More so, the cultural background of an individual plays a significant role in how that individual arrives at their understanding of reality and how the symbols and language one uses are culturally established (Wertsh 1997). In the constructivist perspective, learning is

self-regulated and the individual is actively engaged in the process of learning (Schmuck 2006). The motivations behind the constructivist learner are viewed as being intrinsic (Bares et al 1998), based on an individual's interests, level of confidence, and the challenge of tasks provided (Vygotsky 1978).

Within constructivism, the instructor's role is regarded as being one of a facilitator, rather than a teacher. The facilitator supports and challenges the learner to become an effective thinker, helping them to gain their own understanding of the subject matter, whereas more traditional forms of teaching are based on the transmission of knowledge in a lecture-style manner (Schmuck 2006). Focus is thus shifted away from the instructor as the central point in the classroom, and placed on the individual learner, where interaction between peers and the environment are essential (Vrasidas 2000).

Other aspects that are important in constructivist learning are a free and open experience to allow the individual to find enjoyment in the learning process (Duffy and Savery 1994). Additionally, both Piaget and Vygotsky write on the value of play, stating that situations that are designed with a sense of play help to engage and challenge learners into achieving greater levels of understanding (Vygotsky 1978, Piaget 1969). Further, the constructivist perspective entails an approach that provides learners with the opportunity for contextually meaningful experiences (Fosnot 2005).

Constructivist learning theory has impacted a number of learning theories and educational strategies, such as constructionism. Constructionism emerged through the work of Seymour Papert and his colleagues at the Massachusetts

Institute of Technology as a means to understand how children think and learn

(Kafai and Resnick 1996). Though sharing a number of similarities with

constructivism, such as the belief that the learner actively constructs his/her own

knowledge, constructionism differs in that it focuses almost entirely on the

physical construction of external artifacts with other individuals as a means of

constructing knowledge (Kafai and Resnick 1996). This difference is an important

one, as constructivist researchers believe that many internalized structures

evolve before being exposed to shared experiences, and that knowledge is

constructed both individually and through social interaction without needing to

physically construct artifacts (Bereiter 1994). A final difference between these

seemingly similar learning theories, is the reliance of constructionism on

sociocultural theory principles, which fall outside of the purview of constructivism

(Shaw 1996).

In the following section, works that have used constructivist principles in

the implementation of interactive technologies will be discussed. It should be

noted that a number of works dealing with learning interactives that did not take a

constructivist approach, such as those that used sociocultural or constructionist

principles, were not addressed in this study, as the review focuses on the use of

constructivist principles with regard to interaction design.

2.3.2: Evidence of Constructivist Principles in Interaction Design

Having described constructivist theory and its application within

educational practices, the use of constructivism within interaction design will now

be presented. In the past decade, the field of interaction design and HCI have

started to incorporate constructivist principles into the development of various types of systems.

Within the field of computer supported collaborative learning (CSCL) many computer-based technologies have been developed for use within the classroom (Liaw 2005, Morrison 2003). Research within educational technologies has also moved outside the classroom where constructivist principles have been applied to mobile-based learning. An example of this is the Savannah project that engages children in a simulation where they physically roam around a field collecting information using handheld computers (Naismith et al. 2004). Beyond the physical world, constructivism is applied by researchers within virtual learning environments, such as the NICE project where researchers provided constructivist inspired tools that allow children to cultivate a virtual garden (Roussos et al. 1999). These are only a few examples that demonstrate the use of constructivism in the development of interactive technology. Unfortunately these examples also suggest a limitation of the theory – its applicability lies only within the domain of learning, which is indeed not the case, as the next set of examples will demonstrate.

The first example is a screen-based application that is used to construct virtual environments (VEs). The application has been designed explicitly with constructivist principles in mind to improve the user interface, making it easier to use and maximizing the user's potential to create new designs (Winterbottom et al. 2008). For example, the designers' apply the notion of multiplicity – that multiple truths exist – through providing various paths to construct VEs and

multiple representation of a created environment. Additionally, the creators

worked on engaging the user to explore the set of tools through presenting novel

forms of feedback (Winterbottom et al 2008). Beyond the desktop, constructivist

principles have been applied to augmented-reality applications, such as

GeoNotes, which is a mobile service that runs on cell phones and allows people

to leave virtual messages for each other in different places (Persson et al. 2001).

The designers purposefully designed the system to be open, allowing individuals

to appropriate the technology and create social meaning from its use (Höök

2006). The designers apply the constructivist principle of creating open

environments through providing flexible tools to emphasize the social co-

construction of meaning. Another example involves the design of an interactive

product that emphasizes self-reflection and meaning making through sensory

experiences, called "The Affective Diary" (Lindström et al. 2006). "The Affective

Diary" is a tool that allows users to view and reflect on bodily information that is

collected by a series of wearable sensors throughout the course of the day

(Lindström et al. 2006). The authors claim that they wanted to encourage the

user to make sense of their own experience through providing detailed sensory

information on daily events, such as times of high pulse, or the number of steps

one took during the day. Additionally, the form in which this data is displayed can

be altered and appropriated, allowing the user to create a personal

representation of the information (Lindström et al. 2006). Furthermore, the

authors explicitly state that their model for understanding emotions is based on a

constructivist perspective, where an individual makes sense of these emotions by

interacting with others and the environment, through the use of past experiences (Lindström et al. 2006). The aforementioned examples demonstrate that constructivism is not limited to the design of educational environments, but can also be applied to other areas of interest within interaction design, in particular the user experience.

In recent years experience design has emerged as a strategy within interaction design to better understand the interactions between people and the products they use. As McCarthy and Wright write, "we don't just use or admire technology; we live with it… technology is deeply embedded into our ordinary everyday experience" (2004). Within this emerging discipline, the notion of "experience" has been described in ways that relate to the constructivist principles outlined earlier. Forlizzi and Ford, in discussing the user experience, state that designers can create "situations" or "levers" that people can interact with, but they cannot design an outcome for a user to experience (2000). The authors' statement suggests that they acknowledge the active role of the individual in the making of the experience, while the designed artifacts act as resources that facilitate this process – a perspective that is in accordance with constructivist principles. The authors continue to express the importance for the designer to consider the cultural background and prior experience of users when thinking about the user experience, which are also fundamental qualities of the constructivist approach (Forlizzi and Ford 2000). Additionally, McCarthy and Wright also acknowledge the subjective experience of the individual, and contend that users are not passive, but, "they actively complete the user experience for

themselves" (2004). Analyzing this statement, a clear relation can be made between the authors' understanding of the user and the self-regulated, actively involved, constructivist learner. As a final point, Forlizzi and Battarbee provide a typology of experiences, one of which is co-experience. The authors describe co-experience as the making of meaning through product use, influenced by the physical or virtual presence of others (Forlizzi and Battarbee 2004). The idea of co-experience that the authors describe, relates directly to the process by which constructivist theory explains the formation of knowledge, or what constructivist term the "co-construction of meaning". Through the examples provided above, the relationship between current approaches in the area of user experience and constructivist principles becomes clearer. Despite designers not explicitly using constructivism, it can be argued that many of the principles within constructivism are implicit in their current approach.

2.3.3: Summary

This section has outlined constructivist theory and demonstrated that its principles are being used in a wide range of design contexts, including traditional educational environments, virtual environments, and in mobile computing. This section presents evidence that interaction designers explicitly use the theory to guide design decisions, and argues that constructivist principles are implicit in current approaches to understanding the user experience. In doing so, it provides evidence that constructivism exists as a theoretical commitment within existing design practice, in both explicit and implicit forms.

2.4: From Goals to Evaluation

As previously described in section 2.1.2, design goals are an essential aspect in the evaluation process because they help to establish the criteria used to judge whether a solution is successful or not. In this section, a description of interaction design evaluation methods is provided in order to highlight the shortcomings in existing practices, especially with regards to the evaluation of the user experience.

2.4.1: User-centered Design and Usability

The field of interaction design has, to a large extent, adopted a user-centered design approach to the development of technological artifacts. User-centered design can be understood as both a philosophy and a process, which places people at the centre of the design process, as opposed to traditional approaches that treat technological issues, such as instrumentation, as their main concern (Mahlke 2008). A key concept that is often used within user-centered design is the term "usability". Defined by the International Standards Organization (ISO), usability is the "effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment" (ISO 2941). *Effectiveness* can be understood as the level of accuracy and completeness with regards to satisfying the user's goals. *Efficiency* is described as the amount of time or effort it takes a user to satisfy his/her goal, and *satisfaction*, which is defined as the level of comfort and acceptance of the system by the user (Mahlke 2008). These three factors of usability have become the *de facto* measure of a design's success within the field of interaction design

for some years. These types of measures were indeed useful for instrumental

interactive technologies that were used by expert users, however, as

technologies became more ubiquitous in society, other measures of success

emerged. As early adopters of the term "user experience", Whiteside and Wixon

claimed usability goals needed to be grounded in "something meaningful to the

users", claiming that the designed product would otherwise be "useless" (1987).

In expressing the importance of the user's experience, the authors' suggested

that methods to assess the qualitative aspects of a system were needed in order

to augment existing methods that were based solely on the instrumental aspects

of a system.

2.4.2: User-centered Design Evaluation Approaches

Within the context of user-centered design practice, evaluation methods

should involve actual users, rather than relying on expert opinion alone. While

expert evaluation techniques are useful within interaction design practice, this

study focuses solely on user-based evaluation techniques. To aid in the

description of user-centered design evaluation methods, Dix et al. provide an

adequate overview and group techniques into three categories: experimental

methods, query methods, and observational methods (2004). Each category will

be described below, along with their shortcomings.

2.4.2.1 Experimental Methods

Experimental evaluation is commonly used within fields associated with

computer science, such as human-computer interaction (HCI), due to its ability to

provide empirical evidence to support hypotheses or claims. Within these

methods, users are taken outside of their normal environment, and brought into a

laboratory to take part in a controlled test involving pre-defined tasks, which are

often followed by a questionnaire to grasp user satisfaction (Dix et al. 2004).

Typically, experimental methods probe usability issues such as effectiveness (i.e.

number of errors) and efficiency (i.e. amount of time), focusing largely on

quantifying user performance (Whiteside et al. 1988). Issues pertaining to user

satisfaction are often evaluated through post-experiment questionnaires to elicit

the participant's opinions through applying attitude-rating scales (Mahlke 2008).

Despite benefits of empirical evidence, experimental methods have been

criticized for removing the participant from the context of use (Preece et al 2002),

along with proving difficult to capture interpersonal interactions, as

communication depends largely on context (Dix et al. 2004). Finally, these

methods often treat the user experience, measured as satisfaction, as an

additional aspect to instrumental evaluation, rather than a central concern. In

doing so, it suggests that a high level of efficiency and effectiveness will provide

a satisfying experience. Also, a system could be considered to have good

"usability" if the scores on efficiency and effectiveness are high, despite a low

score on satisfaction. Such are the dangers of evaluating the user experience

using experimental methods.

2.4.2.2 Query Methods

The second grouping of techniques that Dix et al. describe are query

methods, which involve asking the user questions about the interactive system

that pertain to user satisfaction (2004). This approach is based on the principle

that user requirements are best found through directly asking the user and

include such techniques as interviews and questionnaires (Dix et al. 2004). The

authors explain that query methods are useful because they allow access to the

participant's viewpoint in a direct way, along with being both relatively

inexpensive and less time consuming than other methods.

Despite these advantages there are several shortcomings that should be

addressed. The first issue relates to the correlation of the data received through

usability constructs to the data captured through quantitative methods. Some

studies suggest that a correlation exists (Nielson and Levy 1994), while more

recent studies suggest otherwise (Hornbaek and Law 2007). Beyond the issues

pertaining to validity, research on interaction design evaluation practices

suggests that standardized methods of measuring satisfaction are rarely used

(Hornbaek 2006). Finally, query techniques often focus on understanding the

user's satisfaction solely with regards to issues of efficiency and effectiveness.

However as Mahlke points out, the "operationalization" of satisfaction is flawed,

as it implies that user satisfaction can be guaranteed by such instrumental values

alone (2008). Furthermore, current approaches to understanding user

satisfaction often address satisfaction as an outcome of interaction, while the

experience of satisfaction during the interaction is rarely considered (Mahlke

2008).

2.4.2.3 Observational Methods

Observational methods are described by Dix et al. as tools used to gather information about how people interact with technologies in a natural setting. The authors outline several techniques including think-aloud evaluation, protocol analysis and post-task walkthroughs that are used to elicit qualitative information (2004). Similarly, Preece et al. use the term "field studies" to refer to this type of qualitative method, and explain that the choice of technique is often determined by the theory used to analyze the data (2002). The strength of these methods lie in their ability to capture the quality of user interactions within the appropriate context, a shortcoming described in the previous methods. Additionally, concerns in the field of interaction design have extended beyond issues of functionality, which has resulted in an increasing amount of researchers adopting qualitative techniques to better understand the user and his experience using interactive systems.

In spite of this growing trend, there is evidence that techniques used vary considerably, due in part to the variance in theoretical underpinnings used to analyze the data (Preece et al 2002), and also to the lack of standardized evaluation models that address the user experience (Mahlke 2008). In order to address these shortcomings, observational techniques should be grounded in theory, which is to say, that measures used to understand a particular phenomenon should correspond to principles within a theoretical model that was used to guide the formation of design goals. These considerations become ever

more important when dealing with the complexities of evaluating the quality of the user experience.

2.3.4: Approaches to Evaluating User Experience

The user experience is a subject that has been explored from a variety of perspectives, and this subject has been approached with differing epistemological underpinnings. Mahlke provides a review of user experience approaches and groups these into four main categories: phenomenological, design-orientated, emotion-focused, and quality-focused (2008). The phenomenological approach views the user experience as holistic, placing focus on the user's perception of interactive qualities. This involves designing situations where experience can take place, rather than trying to design rigid outcomes. The design-orientated approach deconstructs the user experience into both instrumental and non-instrumental components, which are further broken down into concepts that are used as heuristics for designers. The emotion-focused approach is concerned solely with the role of emotion in the user experience, such as play, joy, or frustration. Finally, the quality-focused approach focuses on non-instrumental aspects of the user experience, which is comprised of the aesthetic quality and symbolic quality of an interactive system (Mahlke 2008).

Through outlining these approaches the author characterizes the ways in which theory and practical understandings of experience can impact the design of interactive systems, and discusses how each of these approaches addresses evaluation. Of those discussed, both the emotion-focused and quality-focused approaches have existing evaluation techniques. Assessment occurs through

deconstructing the user experience into variables that can be studied empirically through experimental or query-based methods (Mahlke 2008). Though this approach may provide empirical results, the danger lies in the simplification of the experience into a set of components, such as "attractiveness", where other possible aspects of the user experience, which could be of equal importance, are not taken into account. Similarly, the design-oriented view also decomposes the user experience into a set of components, but takes a broader approach in considering various instrumental and non-instrumental aspects (Mahlke 2008). One problem with the design-orientated approach is that there are currently no standard methods for evaluating the various elements of an experience that the authors present. From a phenomenological perspective, evaluation is based on qualitative observation and interviews, but like the design-oriented approach, it also lacks a standardized framework to guide evaluation (Mahlke 2008).

It is clear through this brief description of user experience evaluation approaches that further research in the area is needed. On the one hand, those approaches that have demonstrated an evaluative framework do so through reducing the experience into a small set of variables, and thus devalue other aspects of the experience that can be of equal importance. On the other hand, the approaches that take a holistic approach to understanding the user experience lack an evaluative framework to assess their design goals.

2.3.5: Summary

By providing an overview of interaction design evaluation approaches, this chapter has shown a variety of shortcomings. First, the term "usability" was

shown to be insufficient in addressing the complexities of the user experience, as it deals mainly with instrumental aspects of technologies. Secondly, existing methods that are based on usability, such as experimental techniques, are equally inadequate, as they treat the user experience as an aspect of usability, along with removing the participant from the experiential context. As experiential qualities of interaction have gained ground within the field of interaction design, new evaluative techniques have emerged. While these more qualitative approaches have provided a more detailed description of the experience, they suffer from a lack of standardized methods, and often lack a theoretical model to ground their evaluation measures. Efforts towards integrating theory into user experience evaluation has led to multiple perspectives being developed and new opportunities for research in this emerging field.

2.4: Conclusions

This chapter has established that design goals are influenced by a designer's epistemological stance, and has argued that interaction designer's are beginning to use constructivism theory in establishing goals, especially when considering the user experience. Due to the relationship between design goals and evaluation, this perspective implies that technologies being designed with constructivist goals in mind, should also consider a constructivist-orientated evaluation.

Unfortunately, of the studies that have explicitly applied constructivist principles, few have evaluated their solutions from a constructivist perspective. The NICE project (Roussos et al. 1999), GeoNotes (Persson et al. 2001), and the

Savannah mobile experience (Naismith et al. 2004), all use a constructivist

approach, but fail to provide an evaluation of their systems. With regards to those

studies that have presented an evaluation, few have approached it using

constructivist principles. Liaw's system was evaluated using the technology

acceptance model (2005); Morrison's evaluation took an activity theory approach

(2003); while Chen et al. evaluated their system using a discovery learning

approach (2004). Other studies that have performed evaluations include

Winterbottom's design tool (2008), and the Affective Diary (Ståhl and Höök

2008). These projects both evaluated their systems qualitatively, but similar to

the studies discussed above, they lacked a constructivist framework to guide

their assessment, opting instead to ask questions on general usability, perceived

usefulness or emotional affect.

Of the studies that have explicitly used a constructivist approach, only two

provided an assessment based on constructivist principles, both of which were

systems designed for a classroom setting. The first example is Hadjerrouit's

system to help software engineering students program, which evaluated the

system in terms of a student's improvement on tasks, the student's qualitative

perceptions of the system (2005). Despite the author's claims of using a

constructivist approach to evaluate the system, there is only limited use of the

theory's principles. A study that presents a more thorough constructivist

evaluation is Zurita and Nussbaum's Syllable – a mobile classroom assistant to

help students learn basic language skills (2004). In their study, the authors

developed a framework for handheld-based constructivist education in

classrooms, and use the framework to evaluate their prototype within a controlled experiment (Zurita and Nussbaum 2004). The previous example is the only case where various constructivist principles are evaluated and proves useful in understanding how constructivist principles can be operationalized; however due to the study taking place in a classroom under strict learning conditions, it may be difficult to generalize to interaction design applications where learning is not a primary goal. Additionally, due to the lack of studies that include a constructivist evaluation, more research into this area is required in order to develop a standardized framework for interaction design.

2.4.1: Shortcomings

Figure 1 displays a matrix that outlines where the previous constructivist projects and research lay. The matrix is separated into axis that characterizes the type of evaluation (non-constructivist and constructivist evaluation). The non-constructivist category describes those studies that either did not provide an evaluation, or did not use constructivist principles to guide their assessment. The second axis characterizes the context of the system (traditional learning and non-traditional learning experiences). The category for traditional learning experiences deals with systems that were designed for the classroom or for use within the educational system, whereas non-traditional learning experiences involves systems that take interactions outside of such institutionalized environments.
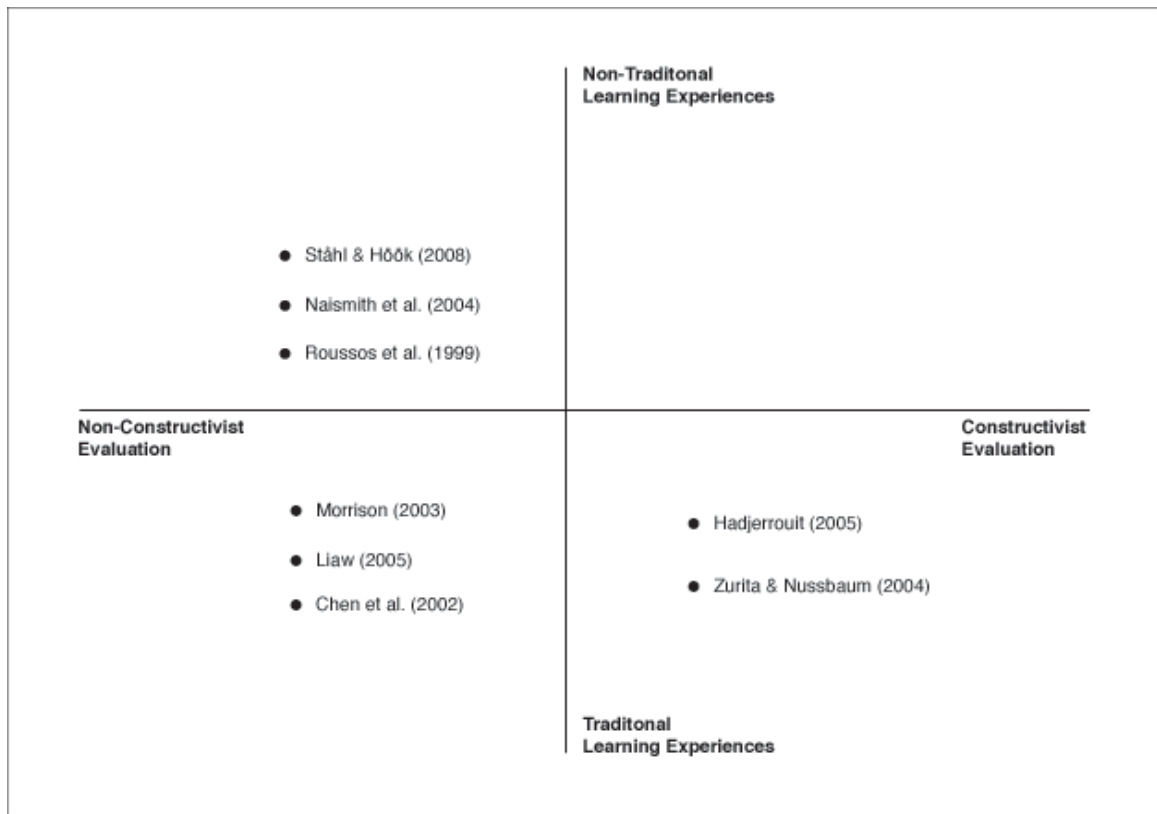
Figure 1: Existing approaches to constructivist evaluation

As the diagram above demonstrates, there are few studies that address constructivist evaluation from an interaction design perspective, and a clear absence of studies that deal with constructivist evaluation outside of traditional learning experiences.

A second shortcoming is that current techniques within the field of interaction design and HCI have difficulties assessing the quality of interaction, especially with regards to the user experience (Mahlke 2008). On the one hand, experimental methods have standardized techniques used by many researchers, but they often remove participants from their natural settings. On the other hand, observational methods are able to capture data on users in their natural settings,

but there is little agreement on an evaluative framework to assess the quality of interaction.

A final shortcoming that has been identified is the increased need to understand how the user experiences technological systems. Of the user experience approaches discussed, the phenomenological approach is of particular interest because it seeks to understand the experience in a holistic manner, rather than deconstructing it into variables that can be experimentally studied. Unfortunately, there are currently no evaluative frameworks that exist to assess the various principles that have been suggested as being important to this user experience approach.

CHAPTER 3: MUSEUMS AS INVESTIGATIVE CONTEXT

This chapter aims to provide the reasoning for selecting museums as a context to study the use of constructivist goals and their outcomes. First, in section 3.1, museums are described as environments that focus on both the design of artifacts, interactives and experiences – issues related to this study's topic. Second, the presence of constructivism within museums and a description of such experiences are described in section 3.2. A final reason for choosing museums, presented in section 3.3, discusses the use of constructivist evaluation methods in museums, which serves to provide this study with useful and validated assessment tools.

3.1: Museum Design: From Artifacts to Experiences

This section describes the museum as a designed environment, where the focus of design has shifted away from the design of the display of artifacts, to the design of the visitor experience, which is the first reason why this was chosen as a context of study.

3.1.1: Early Museums and the Display of Artifacts

The first public museums arose out of eighteenth century Europe through making private treasures, once owned by wealthy statesmen, available to mass audiences (Henning 2006). These new public museums made knowledge

accessible to people who did not have access to educational institutions, while also providing a new pastime that previously only the aristocracy could enjoy.

In these early public museums, objects were often removed from their everyday context and arranged in a community of objects that was guided by specific rules and methods of categorization (Henning 2006). Put another way, there was a purposeful design to the displays that emphasized the relationship between each object, and in doing so, removed the artifacts from their everyday context of use in order to provide new insights about the objects to a largely uneducated public.

3.1.2: Museums and Aesthetic Experience

During the nineteenth century, museums began to reconsider the manner in which artifacts were displayed. The design of museums were guided by the notion that exhibit displays should not only conform to scientific classification, but should be "designed to educate the masses" (Message 2006). Museums began to change, often being reorganized aesthetically to produce "evocative and unexpected juxtapositions, placing artefacts from different periods alongside one another for artistic effect" (Henning 2006). Further, Henning refers to this juxtaposing of artifacts as creating an aesthetic experience, whereby visitors could immerse themselves in the museum visit (2006). During this period, the design of exhibits moved beyond the placement of artifacts and into the design of the museum space in order to shape the visitor's learning experience.

While the design of space was considered, museums at this time still dealt with the problem of the confused, disorientated spectator, whose attention would often drift (Henning 2006). In the early 1900s, museums began using the diorama in order to provide a sense of coherence to the objects on display, while also providing visitors with a "sense of being in the scene" (Henning 2006). Dioramas often used mannequins or taxidermies set in illustrative scenes, sometimes located behind glass, or gated in order to prevent people from entering the designed space. Griffiths explains that the use of dioramas helped to regulate visitor behaviour and limit distracted wanderings often found within cluttered artifact-centred displays that were prevalent in museums prior to the twentieth century (2002). Dioramas and similar forms of displays, such as tableaus and historical reconstructions popular in this era, often restricted visitor movement as visitors needed to take a specific pathway through the museum or were required to stand in a particular place to understand the intended message of the exhibit (Henning 2006). Through considering the movement of patrons, curators demonstrated the use of design to create carefully crafted scenes that would present a more engaging experience for visitors.

3.1.3: Museum Experience and Interactives

Though the use of dioramas and similar techniques were prevalent during the early twentieth century, there were strides being taken towards transforming the visitor from a passive spectator to a more active participant (Witcomb 2006). One of the earliest examples is Duchamps and Keisler's peepholes at the 1947

International Exposition of Surrealism, where visitors could pull a lever and look through a hole cut out in a wall to see a change in the display (Henning 2006).

Beyond Duchamps and Keisler's peephole exhibits, there were also science-based exhibits developed around the same time which featured various technologies in operation which could be activated by cranks or through pressing buttons (Henning 2006). These were some of the earliest interactives used in museum spaces. Witcomb provides the term "hands-on" to further describe interactives and characterises them as using some form of technology, having a physical form, and providing a device that the visitor can operate through physical activity (2006). These techniques often fostered a more actively involved visitor experience in the museum while maintaining the artifact as the centre of focus.

In the founding of the Exploratorium in the late 1960's, the focus on objects in the museum shifted away from the artifact and "towards the demonstration of scientific principles, processes, and phenomena" (Henning 2006). The use of interactives would play a key role at the Exploratorium as it attempted to make the invisible scientific principles of everyday life visible and understandable through the use of hands-on, manipulative physical objects (Hein 1990). For example, in an exhibit that focused on the human body, visitors could use an ECG to measure the electricity from their own hearts, or use another device to test their hearing abilities. In this manner, the design of the exhibits encouraged visitors to become actively engaged in learning by providing people

with the resources to explore and experience the ideas the museum was attempting to communicate.

As technology has since permeated the museum space, another class of interactives that have emerged are electronic museum guides. These guides often come in the form of a personal digital assistant (PDA) that offer information about the exhibit and related artifacts in the vicinity (Patrelli and Not 2005). In some cases, these technologies can take the form of a guided tour that suggests a predetermined path, whereas others act as a resource for visitors, providing access to various types of media upon demand (Wakkary et al 2007). More recently, electronic guides have started to use different approaches to engage visitors, with some using game-like approaches to encourage learning (Stock et al. 2007), while others focusing on more tangible forms of interaction that promote engagement without the use of a screen-based device (Wakkary and Hatala 2006). Regardless of the approach taken, electronic guides often help the visitor to "move beyond the traditional museum label" and act, "as catalysts for enriching the visitor experience, aiming to engage the visitor who often feels at a loss for participating in a museum" (Economou 2007). In describing the use of such technologies in this way, Economou expresses how electronic guides perform a similar function to the interactives used within the Exploratorium, that is, to move the visit away from being object-centred, to being experience-orientated.

3.1.4: Summary

The incorporation of hands-on exhibits and interactive museum guides have shifted the focus of the museum visit away from the presentation of artifacts to a more educational, physically engaging experience. This is a trend that is mirrored in museum design itself, as is evident in the shift from an object-centred exhibit approach, to an experience oriented perspective. Museums have become more attentive to the visitor's own experiences and values, which emphasizes an appeal to people's emotional and sensory responses (Hein 2000). In order to accommodate for these changes, the design of exhibits and museums have shifted towards the use of learning theories to adopt various techniques and principles, many of which are based on constructivist thought.

3.2: Constructivism in Museums

The traditional view of learning in museums is often described as the "acquisition of fact-based knowledge", which occurs through the transferring of knowledge through didactic exhibits (Black 2007). Though this approach is still present in museums today, experts have started to rely on social and learning theories to help develop a richer educational component to the exhibits in the museum. According to Reeve and Woolard, a number of theories are regularly used, including Gardner's theory of multiple intelligences, flow theory, and also constructivism (2006). Of these approaches, constructivism has dominated the way in which museum experts think about the nature of learning in museums (Black 2007). The acceptance and use of constructivist theory was a second

reason for selecting museums as a context to conduct this study, as there was a

high probability of its use by museums within the local area.

3.2.1: The Constructivist Museum

According to George Hein, there are three basic ideas that are needed in

order to hold a constructivist view: (1) that knowledge is constructed in the mind

of the learner, (2) that learning is active and engaging, and (3) that the context be

physically, socially, and intellectually accessible (Hein 1998). Beyond these three

components, the author provides a series of guidelines by which one might

develop a constructivist museum experience.

The first element in Hein's guideline relates to the need for the visitor to be

able to associate the learning situation to his previous knowledge, be it an

exhibit, a display case, or interactive (Hein 1998). The author explains that

museums should address the need for the visitor to be able to make connections

to both the place and the content. The first associations the visitors makes is with

the actual building, its location and appearance. Hein suggests that museums

should work on developing a comfortable environment where visitors feel free to

move in the space and be able to orient themselves in it. The second type of

association is called conceptual access, and it deals with the ability of the visitor

to associate the content on display to their own previous knowledge. In order to

help visitors make connections to exhibitions, Hein suggests that some of the

material on display should be familiar to visitors. By doing so, it provides a

conceptual bridge for the visitor to understand artifacts on display that are

unfamiliar to the visitor (Hein 1998).

The second element in Hein's guideline is an exhibit's ability to address various learning modalities in order to appeal to various senses. The author contends that presenting information in the various senses (such as sight, scent, and touch) will engage visitors in a style of learning that they feel most comfortable with. Another aspect that relates to learning modalities is providing different levels of access to accommodate for different learning styles. Hein provides several examples, such as "layered text" – text-based didactics that display information for different age groups. Hein also states that the use of supplementary information and demonstrations located in close proximity to the exhibition are well suited to the constructivist perspective (Hein 1998).

A third element the author provides relates to the amount of time spent in the museum. Hein contends that the museum visit should try to maximize the length of time visitors spend with a particular exhibit in order to provide them with an optimum opportunity to make meaning from it (Hein 1998). Unfortunately, the author does not provide any methods to assist designers in developing exhibits that apply this principle.

The fourth element Hein discusses is the importance of fostering a high level of social interaction in order to allow learners to move beyond their individual experience. This concept is related to the notion of cooperative learning, where students are encouraged to share information with each other in order to increase their own learning, while also improving their own ability to learn. Learning in this manner is seen as a social activity. In a constructivist museum, Hein explains, museums should be mindful in the design of spaces,

exhibits and programs to promote social interaction (Hein 1998). An example of this could be the design of exhibits that allow multiple people to gather around it, which may provoke members of the group to discuss the artifacts on display.

A fifth element in Hein's constructivist guidelines is that exhibits and museums should be developmentally appropriate for their visitors. The author contends that museums have to consider various stages of intellectual development, rather than developing exhibits and programs for a particular group, such as children or adults (Hein 1998). The author suggests two approaches to address this issue. The first is to create separate galleries for adult and children, where exhibits are designed specifically for each group. The second approach the author discusses is to design one exhibit for both groups, but with labels and materials designed for each group. The author contends that there is "no simple formula" to address the issues posed by the different development states of the visitors (Hein 1998), which suggests the need for further research in this area.

The final element that the author provides is that the experience should be intellectually challenging for the visitor. Hein refers to the "zone of proximal development", a Vygotskyan term that signifies the learning space that is slightly beyond a person's current understanding, but not too far beyond their understanding to cause them to be disinterested due to the difficulty of the particular activity (Hein 1998). The author suggests that designers should create situations where the visitors will be challenged, while at the same time provide materials that will be familiar to them so that they can "rise to the challenge"

(Hein 1998). The author explains that this constructivist principle is currently underdeveloped and proposes the use of empirical studies to further an understanding of how exhibits can be designed to be more developmentally appropriate for a range of visitors.

3.2.2: Summary

This section described that constructivism is accepted and often used within museums, which was an important factor in selecting museums as a context of investigation for this study because it allowed a level of certainty of finding a site that applied these principles. Additionally, the description of Hein's constructivist principles serves the purpose of better understanding what a constructivist museum consists of, while also providing a baseline from which to discuss this study's findings.

3.3: Constructivist Assessment in Museums

A final reason for selecting museums as a context to study the phenomenon of how constructivist design goals relate to their outcomes is the history of assessment techniques that have been established to understand visitor engagement. Despite the large number of studies, there are relatively few that have evaluated the visitor's experience from a constructivist perspective. Before conducting this study, several constructivist evaluation methods were considered, such as Roschelle's use of clinical interviews to elicit information from museum visitors (1995), or Bailey et al.'s constructivist model that gathers data from several sources such as visitor tracking, exit interviews, and interactive

observations (1998). Both of these studies offer insights into the assessment of constructivist learning, but are not without problems in their scope. Roschelle's model was limited to a single data collection approach, which seemed inappropriate for this study. Bailey's model on the other hand, provided various types of data, but was designed specifically for the museum that the researcher was investigating, and would have required significant modifications to re-purpose it for this study.

A third model was considered that addressed both the need for multiple data sources and the need for a replicable model that was validated. This model, called MARVEL (Museums Actively Researching Visitor Experiences and Learning), was developed through a collaboration of institutions and researchers in Australia in order develop a set of "tools" for any cultural institution, to be used by staff with very little evaluation experience (Griffen et al 2005). Due to these positive characteristics, the MARVEL model was selected as the assessment tool to be used in this study. Further details regarding the MARVEL assessment tool will be presented in the following chapter.

3.4: Summary

This chapter has provided the reasoning for selecting museums as a context for this study's investigation. First, museums were described, as designed environments that not only focus on the placement of artifacts, but on issues of interactivity and experience – issues that are pertinent to the topic of this study. Next, the use of constructivism in museums and guidelines for its application were described, which provided the researcher with the necessary

understanding to select constructivist case sites, and a lens to analyze this

study's results. In the final section, constructivist assessment models were

described and a method was selected, which in turn, provided this study with the

necessary tools to study visitors.

CHAPTER 4: METHODOLOGY

This research aims to describe the relationship between design goals and outcomes within the field of interaction design. The inquiry is based on a study involving the investigation and analysis of cases where constructivist goals were employed in order to influence the experience of family visitors in museums. The study's objective is restated in section 4.1, which is followed by a description of the methodological approach in section 4.2. In section 4.3 research questions and propositions are presented. Section 4.4 describes the research design and data processing methods used. Data analysis and coding techniques are then described in section 4.5, followed by a summary of the chapter in section 4.6.

4.1: Research Objective

The objective of this study is to investigate the relationship between constructivist design goals, expressed as intentions, and the outcome produced through their employment in order to better understand the value of constructivism to the field of interaction design. This exploratory study also aims to identify possible components to be included in a framework to help interaction designers shape and evaluate the user experience more effectively.

To investigate this phenomenon, there was a need to locate multiple sites where constructivist principles guided the design of technology, and where data could be collected on participants interacting with the designs. These

characteristics led the researcher to choose museums as sites to study this phenomenon. As described in chapter 3, museums are designed environments where constructivist principles are often applied, and through a rich history of research conducted in these contexts, they provide validated techniques that this study can benefit from.

4.2: Methodological Approach

4.2.1: Qualitative Research

Qualitative research is valuable in explaining social phenomena and uses multiple methods that are interactive and humanistic (Creswell 2003). Additionally, qualitative research provides a rich, holistic, description that focus on process, meaning, and understanding (Merriam 1998). Creswell describes qualitative research through the use of five approaches: narrative, phenomenology, ethnography, grounded theory, or case study (1994). In describing these approaches, the author maintains that case studies, in particular, are useful in describing processes, activities and events with considerable detail (Creswell 1994); and for these reasons, a qualitative case study approach was deemed appropriate to guide my study.

4.2.2: Case Study Research Method

Case studies are an empirical method, well suited to investigate questions that cannot be addressed through controlled experiments. They rely on qualitative analysis and sometimes, quantitative methods, to connect cause and effect. Additionally, they are particularly useful in cases where the researcher has

little control over key variables (Easterbrook et al. 2005). The approach has been widely used in sociological studies, especially when a holistic, in-depth investigation is required (Feagin et al. 1991). Within case studies, the researcher considers multiple-perspectives, including the perspective of the participants, relevant groups surrounding the participants, and the interactions between them (Feagin et al. 1991). The strength of the case study approach lies in its use of multiple sources of evidence, which enable the researcher to develop "converging lines of inquiry" through the triangulation of data (Yin 2003).

Yin, in describing the benefits of the method, presents four applications for a case study model: (1) to describe real-life interventions where the phenomenon occurred, (2) to describe the phenomenon itself, (3) to explore situations in which the phenomenon being assessed has no clear set of outcomes, and (4) to explain causal links in real-life interventions (2003). Though the evaluation of technology in museums may pertain to all of the categories previously listed, this study focuses on the first three categories and takes a descriptive approach.

4.2.3: Rationale for a Descriptive Case Study Approach

Descriptive case studies are beneficial in presenting detailed accounts and are often applied when limited research exists on the subject matter in question (Merriam 1998). With regards to this research topic few studies investigate constructivist principles and their relation to outcomes experienced, especially with regards to the design of interactive technology. Additionally, results of descriptive case studies often provide conceptual frameworks to help guide future research, which is a goal of this study. Finally, this type of case

study design is useful when a researcher asks "how" and "why" research questions (Yin 2003). My study attempts to understand how constructivist theory may be beneficial to interaction designers, and describes in detail how design decisions based on this theory relate to the visitor's experience in the museum.

4.2.4: Reliability and Validity

Reliability refers to the extent to which the findings of a study can be replicated and whether or not the same results would occur in a repeated study (Merriam 1998). Yin addresses this issue and explains that the goal of reliability is to "minimize the errors and biases in a study" which can be achieved through the use of a case study protocol (2003). The protocol is a research document that includes both the instrument and procedures for researchers on how to use the instrument, along with any other information used to conduct the study at the case sites. In my study, a protocol was used to keep procedures for data collection consistent among all sessions and across both case sites. For further information on the case study protocol please see appendix G.

Beyond reliability, qualitative research focuses heavily on the dependability and consistency of findings in a study. To address these factors, Maxwell provides a checklist of seven strategies that help to avoid threats to a study's validity. In my study, I have applied six of the suggested strategies: long-term involvement, collection of rich data, triangulation of data, quasi statistics, comparison of data, and respondent validation (Maxwell 2003). The author notes that not every strategy will work in a given study, and this is the case with this research investigation. The remaining validation strategy, *intervention*, was not

applied to this study as it entails the design of an intervention to understand the

effect on a particular phenomenon under investigation. This study chose not to

adopt this approach, as the investigation focuses on intentions and outcomes

that occur without purposeful influence on the phenomenon of investigation.

The first strategy that helps to ensure a study's validity relates to a

researcher's *long-term involvement* with the case. Maxwell contends that the

"sustained presence of a researcher in the setting studied", along with the

repeated observation and interview of participants allow for greater opportunity

for overlap in findings (2003). My study addresses this factor through conducting

multiple sessions at each site, along with conducting multiple interviews over a

period of a month. Through collecting data over a period of time, a researcher is

able to collect *rich data*, which is the second strategy the author suggests. The

transcription of interviews and observation sessions is the third strategy and

helps to limit researchers from making biased conclusions (Maxwell 2003). This

research study aimed to collect both audio and video data that captures visitor

interactions in situ, along with collecting verbatim statements directly from

participants through the transcription of interviews. *Triangulation*, a fourth

strategy, refers to the collection of data through multiple sources (Maxwell 2003).

Beyond collecting audio and video data at various points throughout a period of a

month, my study also collected various types of data, including in situ

observations, and interviews from both designer and family groups. Additionally,

observing various groups in multiple cases ensured that triangulation of data was

addressed. *Respondent validation* was a fifth strategy employed in my study and

refers to soliciting feedback about the data collected from the people that were studied (Maxwell 2003). In this study, audio transcriptions from interviews were sent to the designer participants in order to receive comments and further feedback. A sixth strategy, *quasi-statistics,* entails the use of simple numerical results that can be found in the data. This study uses this approach by tabulating the frequency of themes and codes found within the interview and observation data. In doing so, it provides evidence not only on how a particular theme is addressed, but how often it is occurs, which allows these findings to be compared to one another. *Comparison* is the seventh strategy that Maxwell suggests (2003). As this study's aim is to understand the relationship between intention and outcome, it requires the use of this strategy. Additionally, the study compares the findings from two different cases, in order to provide further validation of the results.

A frequent criticism of case study research is that the results are difficult to generalize, however both Yin (2003) and Stake (1995) argue against this perspective. Yin explains that the goal of case study research is to "expand and generalize theories (analytical generalization) and not to enumerate frequencies (statistical generalization)" (2003). In other words, case study research is not concerned with precise sampling of a defined population to which the results can be extended, but rather, it is based on the development of theory that can be applied to other cases. Such is the case in my study in seeking to develop a conceptual framework for the design of meaningful interactive experiences.

4.3: Research Questions and Propositions

The research questions and propositions are stated as following:

Q1: How are constructivist intentions expressed by designers?

P1: The use of a descriptive approach to each case site where designers have expressed their use of constructivist theory will provide details regarding how they use constructivist theory.

Q2: Is there a relationship between the constructivist intentions described by the designers and the outcome expressed by family groups who visited the museum?

P2: In comparing constructivist intentions to the outcomes experienced by family groups, patterns will emerge that demonstrate that the constructivist principles employed are experienced by members of the family group.

4.4: Research Design

This section describes the design of the study, and each case that was investigated, along with the case study protocol used.

4.4.1: Multiple-Case Study Approach

A multiple-case approach was chosen instead of a single-case approach in order to better understand the phenomenon in question and provide further reliability to the findings. The multiple-case approach is also commonly used for comparative reasons, a purpose shared with this study. This study investigates the relationship between designers' goals, expressed as intentions, and the outcomes experienced by family visitors. It uses an embedded approach, which is described by Yin as a study that contains more than one unit of analysis and used when attention is given to different aspects of the phenomenon under investigation (2003). In this study there are two units of analysis: designers

(individuals responsible for the creation of the exhibit and related technologies) and family groups. Family groups are defined within this study as a group of blood related individuals comprised of at least one adult and one child.

Each site was carefully chosen using a literal replication logic, which is applied when similar results from each case site is predicted (Yin 2003). Using this method to select sites, each museum was chosen based on their explicit use of constructivist theory, similarities with regards to their target audience, the use of interactive technology, and the ability to gain access to designers who were responsible for the exhibit. Due to the limited number of museums located in the lower mainland area, the time to conduct multiple cases, and limitations on research funding for this project, two cases were selected: Kurio at the Surrey Museum; and BodyWorks 2 at the Telus World of Science.

4.4.1: The Cases

Each case will be described briefly below, including the case site and each unit of analyses: designers and family groups. A more detailed description of each case will be presented in the following chapter.

4.4.2.1: Kurio at Surrey Museum

The Surrey museum is a natural history museum located in Cloverdale, British Columbia. The museum features a number of exhibits that focus on various historical and present-day issues in the community. The museum has on display various artifacts from their respected time-period, text-based didactics, and a series of audio kiosks where visitors can listen to interviews of important

figures in the community. Additionally, the museum features several televisions where pre-recorded videos are shown. In the summer of 2008, a team of researchers from Simon Fraser University installed an interactive museum guide system in the museum, named Kurio, which augmented a number of exhibits. The system used constructivist principles to guide its design and included several components including: a tabletop display, tangible user interfaces, and a PDA device.

4.4.2.1.1: Unit of Analysis: Designers

The designers of Kurio include those people who were responsible for the interactive experience of the guide system. Though the development of Kurio involved many people, only two designers were selected for this study due to their involvement with the application of constructivist principles in the developed system. Additionally, the author of this study played a significant role in the development of the interactive experience, which provides further insight for this study.

4.4.2.1.2: Unit of Analysis: Family Groups

In the Kurio case, participants were recruited through local school boards and home schooling contacts, and were all Surrey residents. From this site, we recruited 3 families, consisting of 4 adults (3 females / 1 males) and 6 children (3 females / 3 males). The children's age ranged from 14 years old to 7 years old. All participants were given free access to the museum and were given a movie voucher that could be redeemed at a local cinema.

4.4.2.2: BodyWorks 2

The second site that was selected for this study was BodyWorks 2 at Telus World of Science in Vancouver, British Columbia. The exhibit was chosen after an initial meeting and walk through with the exhibits manager. The exhibit is located on the second floor of the science centre, and is separated into two parts, located in plain site of each other. The exhibit focuses on issues surrounding the human body, such as reproduction, bone structure, and the purpose of various organs. The exhibit was designed for both young and adult visitors and was designed with constructivist principles in mind. The exhibit hosts a series of artifacts that can be manipulated, text-based didactics, along with a variety of interactive technologies, such as traditional screen-based interactives, and tangible-based technologies that react to physical manipulation.

4.4.2.2.1: Unit of Analysis: Designers

The two primary designers responsible for BodyWorks 2 took part in this study and were selected based on their high level of involvement in the project. One designer was responsible for developing the content and making decisions based on the learning models, while the second designer was responsible for shaping the ideas of the exhibit into their physical, presentable form. Through conducting a brief pre-interview, the designers had stated that the learning theory that they used to guide the design of the exhibit was constructivism, which provided further validation that constructivist principles were at work in this case.

4.4.2.2.2: Unit of Analysis: Family Groups

In the Science World case, participants were recruited through the museum's membership list with help of a staff member. In total, we recruited 3 families, consisting of 5 adults (3 females, 2 males), and 6 children (4 females and 2 males). The children's age ranged from 12 years old to 6 years old. Similar to the previous case, participants were given a voucher for the IMAX cinema located inside Science World.

4.4.2: Case Study Protocol

In order to guide the data collection process, a case study protocol was developed and used. The protocol helped to determine which data was going to address the research questioned posed, along with providing an outline of the procedures used in the field.

To address the question – *how do designers use constructivist goals in developing interactive technology?* – information will be gathered through semi-structured interviews with the designers along with any documents gathered from each of the sites. With regards to the question – *is there a relationship between the constructivist goals described by the designers and the outcome expressed by family groups who visited the museum?* – data will be gathered from family groups through semi-structured interviews, and observation sessions. This data will then be compared to the data collected from the designers in order to describe the relationship.

The field procedures were designed to be consistent across both cases, and the procedures for data collection on both units of analyses are described below.

4.4.2.1: Field Procedures: Designers

A procedure was developed for the designer interviews, which was used to elicit information about their goals, intentions, how constructivist principles were applied, and the challenges they faced. These questions were based on constructivist museum literature, in particular, the principles presented by Hein (1998) that were discussed in chapter 3. The semi-structured interviews consisted of various questions that were designed to be flexible, while also incorporating more structured questions that were prepared in advance. Merriam describes semi-structured interviews as a useful technique because it provides sufficient direction for the interview, while also allowing the interviewer to respond to emerging ideas elicited from the participant (1998).

4.4.2.2: Field Procedures: Family Groups

The procedures that were used to collect data on the family groups were based on a constructivist method developed as part of the MARVEL. The instruments that were developed incorporate various methods of data collection at different stages of the study and have been refined through their use in various research studies (Griffen et al 2005). Though various museum methodologies exists (see Sterry and Beaumont 2006), based on the aforementioned reliability of the protocol, its ease of use, its focus on a constructivist approach, and its use

of multiple sources of evidence, the MARVEL "toolset" was selected as a protocol for this case study.

The protocol consisted of four stages: the pre-visit, the museum visit, the post-visit, and a final interview. Each stage is described below, including the instruments used and the modifications made.

Upon completion of the recruitment process, participants were invited to one of the two museums and asked to fill out the necessary ethics forms. Further details were explained about the project and the research team was introduced. Each participant was wired with a lapel microphone and audio transmitter, which conveniently kept the participants' hands free while still allowing the research team to capture audio data through the use of a digital recorder. The pre-visit stage of the study consisted of an informal interview that lasted between 10-15 minutes, which served as a means to understand the family's previous experiences in museums, their visit history at the case study site, and the frequency of visits to other museums. This data was not coded in this study, but was used to understand the visitor's history, while also providing the opportunity for the participants to be more familiar with the researcher and the museum environment.

The interview was followed by an in situ observation session within the museum. During this second stage of the study, we invited participants to interact with a set of exhibits that our study focused on. Within the Kurio case, two video cameras were used to capture the family groups within the museum, while in the Science World case observational notes were used instead. This decision was

influenced primarily by the reluctance towards the use of video by the staff at Science World. Despite this drawback, we were given permission to photograph participant interaction, taking care to avoid capturing non-participants. In both cases auditory communication was captured through the use of digital audio recorders in the same manner by which the initial interview was recorded.

In order to guide the observation sessions, the study used an instrument developed by the MARVEL project used to uncover visitor engagement, which involved recording both visual observations and auditory communication between members of the family. The visual observation data provides an indication of the extent of use of hands-on exhibits, along with providing information on data that does not involve verbal communication, such as reading, manipulating, and looking at artifacts. The auditory data is intended to provide a deeper understanding of the participant interactions; how individuals are relating to their previous experiences, and how the artifacts stimulate discussions among the group. Additionally, the auditory data provides a means to capture emotive responses from participants that is difficult to capture through visual observations alone. The MARVEL tool is further described in more detail within the analysis section of this chapter.

Upon completion of the museum visit, the families were invited to participate in the third stage of the study – a semi-structured exit interview. This interview was meant to debrief the participants, and to inform them of the self-administered interview protocol, and was not coded for visitor responses.

The final stage of the protocol consisted of a self-administered interview to be conducted at a later date. Due to the nature of constructivist theory, where learning is viewed as an ongoing process, it was important to capture the impressions of the museum visit over a longer period of time. Each parent from the family groups was given a digital audio recorder and was asked to interview their family 2-4 weeks after the initial visit. Along with the audio recorder device, we provided instructions on its use, along with a set of questions we wanted them to ask. The use of this method was based on the notion that having a parent conduct the interview in a familiar setting would elicit more authentic responses than in a non-familiar setting with a researcher present. The interview questions were meant to gather information on the participant's impressions of the visit, the impact of particular parts of the exhibit, and to know if the visit provided any new understandings.

4.5: Data Processing and Analysis

4.5.1: Data Processing

Once the data was collected, the audio data was transcribed and the video from each session was digitized. The audio and video were enumerated using an identification number in order to conceal the identity of the participants. Additionally, the digitized audio and video data were kept on a computer that required a login. In order to keep the identity of the participants anonymous, the real names of the participants have not been used. The data from each case site would become an information database from which findings were derived.

4.5.2: Data Analysis for Designers

According to Merriam, the goal of data analysis in case study research is to communicate to the reader a deep understanding of the case; the researcher needs to first organize the data collected and consider which data analysis tools will best convey a deep understanding of the phenomenon being studied (1998). To analyze the data collected on designers, the procedures outlined by Merriam were used, which include three phases: (1) descriptive accounts, (2) categorization of data into themes, and (3) development of assertions (1998).

4.5.2.1: Descriptive Accounts

Providing descriptive accounts is often the first level of data analysis and begins with the process of open coding. Open coding refers to the partitioning and labelling of collected data that helps to develop themes (Creswell 2003).

Open coding was used on the designer interviews and supporting documents provided from each museum site. The designer data from both cases were coded together to provide an understanding of themes across the cases. A research-assistant and myself coded the interview transcripts from both cases independently in order to highlight issues of interest that applied to the study's research questions. I alone coded the design documents. Independently and applying categorical aggregation, the research-assistant and I collapsed the codes into a manageable set of categories, a process described by Creswell (2003). The codes were then reviewed and further aggregated, with any discrepancy discussed and resolved by going over the initially coded transcripts together.

4.5.2.2: Themes

The next step in the process of qualitative data analysis involves the development of themes. This step involved comparing, contrasting, and integrating the developed categories in order to aggregate them into higher order categories (Creswell 2003). This process was conducted independently and provided the researcher with the ability to synthesize the findings from the designer unit of analysis.

4.5.3: Data Analysis for Family Groups

Data from the museum observation sessions was used to understand how the visitor engaged with the exhibit. The interviews were then analyzed to understand how the visitor experienced the visit, and gain further understanding on how they learned. Data collected from the pre-interview was not analysed for this study, as its purpose was to better understand and help the participants become more comfortable with the study's environment.

4.5.3.1: Descriptive Accounts

In order to understand visitor engagement, a coding instrument developed by the MARVEL project was used to analyse the video, audio, and photographic data that was collected from the museum observation sessions. Creswell describes such codes as "pre-figured", and explains that researchers should still remain open for "emergent" categories (2003). In order to code the video data, the video was separated into ten second segments, which were individually coded by two researchers independently. The coded data was then compared

using a consensus model for inter-rater reliability. Transcriptions of the audio

data were coded separately based on the method described by Griffen et al.

(2005). The MARVEL code consisted of seven indicators for engagement, which

are included in table 1.

Similarly, the MARVEL instrument was also used to code the transcripts

from the family interviews, though minor modifications were necessary to

incorporate participants' reflections, as some codes made less sense given the

in-situ format of the initial coding instrument.

Category	Behaviour	Data Type
Showing responsibility for learning	• Know what they want to look for / making choices •Writing/drawing/taking photos • Talking to themselves • Deciding where and when to move	• In-museum video • In-museum visual notes • In-museum photographs • In museum audio transcripts
Actively involved in learning	• Standing and looking/reading • Exhibiting curiosity and interest by engaging with an exhibit • Absorbed, close, concentrated examination	• In-museum video • In-museum visual notes • In-museum photographs • In museum audio transcripts
Purposefully manipulating and playing with objects and ideas	• Handling exhibits with care and interest • Purposefully 'playing' with exhibit elements/using hands-on exhibits	• In-museum video • In-museum visual notes • In-museum photographs
Making links and transferring ideas and skills	• Comparing exhibits • Referring to prepared questions • Comparing/referring to previous knowledge /experiences	• In museum audio transcripts
Sharing learning with peers and experts	• Talking and pointing • Pulling others to show them something • Willingness to be pulled to see others' interests • Group members talking and listening • Talking to adults/experts	• In-museum video • In-museum visual notes • In-museum photographs • In museum audio transcripts
Responding to new	• Evidence of changing views	• In museum audio transcripts

information or evidence	• Evidence of discovering new ideas	
Showing confidence in personal learning abilities	• Asking questions of displays • Explaining to peers • Reading to peers • Comparing information from another source	• In-museum video • In-museum visual notes • In-museum photographs • In museum audio transcripts

Table 1: The MARVEL code for engagement in a museum setting

4.5.3.2: Themes

Similar to the manner in which the categories developed for the designer unit of analysis, categories were also aggregated into higher order themes for the family groups. The MARVEL categories and other categories that emerged from the data were compared, contrasted, and integrated in order to more clearly communicate the findings.

4.5.4: Development of Inferences, models and assertions

The final level of data analysis within qualitative research involves the development of inferences, models, and assertions (Merriam 1998). In the previous stage of data analysis, categories were used to describe the data, generate themes, and interpret data. For each case site, the themes developed from both unit of analysis were compared and contrasted with each other in order to understand the relationship between the designers' intentions and the outcome experienced by the family groups.

Upon completing this analysis for each case site, the sites were then analyzed using a cross-case synthesis method. Yin describes the cross-case

synthesis as an approach used to aggregate findings across several sites (2003). By using this approach, similarities in each case were compared and discussed. Following the cross-case synthesis, models and assertions were developed and then related to existing literature in the field.

4.6: Summary

This study was designed to understand the value of constructivist principles to the field of interaction design through investigating the relationship between designers' constructivist goals and the outcome experienced by visitors who interact with particular exhibits. The study took a descriptive multiple-case study approach in order to describe the application of constructivism to the design of interactive exhibits. Through presenting the procedures for data collection and analysis, along with describing the methodology, this chapter has shown that the descriptive multiple-embedded case study approach is sufficient to address the research questions posed in this study.

CHAPTER 5: ANALYSIS OF CASES

This chapter presents a description of two cases that were the focus of this study. The analysis presents each case independently; first, describing the designer unit of analysis, then the family unit of analysis, followed by comparison between the family and the designer units. The analysis is written in narrative by theme, and was developed from multiple sources of data including semi-structured interviews, video observations, visual observation notes, and audio recordings of family visitors within the museum.

5.1: Kurio at Surrey Museum

The Surrey Museum features a number of exhibits that focus on various historical and present-day issues in the community. The museum has on display various artifacts from their respected time-period, text-based didactics, and a series of audio kiosks where visitors can listen to interviews of important figures in the community. A team of researchers from Simon Fraser University installed an interactive museum guide system in the museum, named Kurio, which augmented a number of exhibits. The system included several components including: a tabletop display, tangible user interfaces, and a PDA device.

Within the Kurio project, the designers were selected based on their contributions to the design of the visitor experience and overall outcome of the project. Participant 7 is currently a Ph.D. candidate within the field of interactive

technologies. Participant 8 was the principal investigator of the project and is a tenured design professor with 15 years of experience in academic research and professional practice of interaction design.

5.1.1: Analysis of Designers

From the data collected for this study, eight themes were identified from interviewing two of the designers who helped to develop Kurio. The themes are presented in figure 2 in order of frequency of appearance. The final theme is presented independently, as it does not include designer intentions, but rather the challenges the designers faced, which will be discussed in the following chapter. The use of simple statistics in this study should be interpreted as a means to provide an overall picture of frequency, and to support the similarity between the qualitative findings in both interviews, rather than a means to provide quantitative significance.

Insignificant statements were extracted from the interview transcripts and were not coded (25% of total statements). The insignificant statements consisted of introductory sentences, replies to misunderstood questions, along with sentiments regarding the outcome of the project, such as "I thought it did better than I thought it would be", (participant 8). A number of statements regarding the collaborative design process and description of the design process were deemed insignificant, such as "near the end, we found ourselves meeting more often to resolve more technical issues with the system" (participant 7). Beyond this, there were numerous statements that reaffirmed a previously stated perspective, such

as "so that was interesting" (participant 8), that were not coded, as they did not

provide further evidence and were difficult to code when taken out of context.
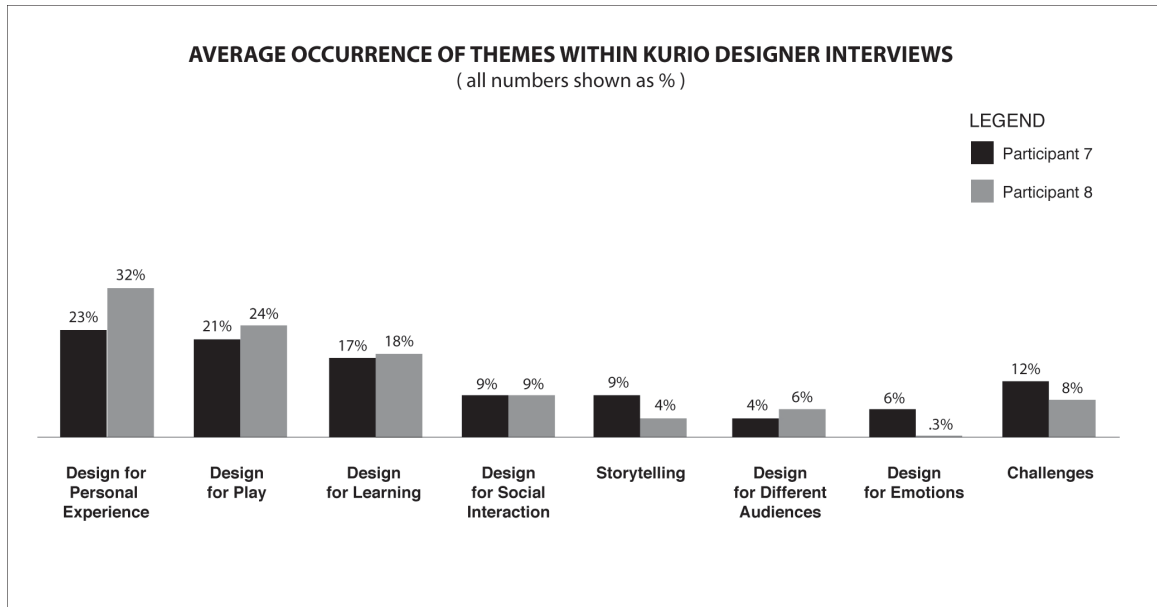
Figure 2: Coded responses by themes and participant for Kurio designers

5.1.1.1: Theme 1: Designing for Personal Experience

This theme appeared the most within the designer interviews, which

signifies its importance with regards to intention. Statements were coded from

two participants with the following frequency (in all the reported themes, the

number of related statements and percentage based on all of their statements

are presented): participant 7 (27 statements, 23%), and participant 8 (123

statements, 32%).

In this theme, the designers wanted to provide a goal to work towards,

provide visitors with the resources to achieve the goal, and provide the means to

make sense of the content by situating the goal within previous knowledge.

Designers spoke of creating design resources that fit people's past experiences

and could be used to generate new understandings of things within the museums. For example, a designer commented on the intent of tangible devices: "it needed to be that resource for imagination, and so people still had to relate to it, and then take it somewhere else" (participant 8).

The designers spoke of the importance of the visitors bringing their own interpretations to the museum through designing a system that was open-ended and flexible. For example, one designer said: "We had so many components to the system, and constructivist learning was really about flexibility and about brining your own understanding to it" (participant 7). A key concern was to take into account previous knowledge as a starting point for enabling people to move from what they already know to something new. In Kurio, the system used individualized user models for each family member in order to provide each person with tasks at an appropriate level for their intellectual development. "So we knew going in, things like their name, their age, and then as they interacted with the system, we developed an individual history for them" (participant 7).

5.1.1.2: Theme 2: Designing for Play

This theme was the second most frequently coded. Statements were coded from two participants with the following frequency: participant 7 (25 statements, 21%), and participant 8 (91 statements, 24%). The play theme consists of several sub-themes: *Metaphors, Designing for Imagination, Use of Game-Play,* and *Variety of Interactions.*

Metaphors

Metaphors were commonly discussed as a designers' means to relating to personal experience and creating a platform for imaginative play. The opportunity for a metaphor can shape the form of a tangible interactive to create imaginative space. For example, a designer of Kurio spoke of how one of the tangibles could "read" text and had a particular shape to it: "The reader was enough like a magnifying glass, but it wasn't a magnifying glass" (participant 8). Furthering the use of metaphors, the designer remarked: "It had to be a little bit larger to create that playful space, like larger toys" (participant 8).

Designing for Imagination

In this sub-theme designers expressed the need to create something new through sparking the imagination with something familiar. The expectation of designers was that people are going to try something new but the mechanism for interaction needed to be familiar. Aesthetics, familiarity, and imagination all played a role: "They [tangibles] had to be imaginative objects. You know my smartphone is a smartphone, so you can't imagine what else it could be. It needed to be that resource for imagination, and so people still had to relate to it, and then take it somewhere else" (participant 8). Imagination can create continuity between the experience and visitors' everyday lives:

> "It made it a little more playful and I imagine it was something that they talked about when they got home – 'oh we got to be time travelers', time machines, that kind of stuff…" (participant 7).

Use of Game-play

Game-play emerged as a way to create and shape engagement. Game-play provided flexibility in the experience and structure:

> "So I think that there was sufficient structure that was required for the narrative and for the game that they were playing, but that they really had flexibility within that structure to take the time they needed to take and do the things they needed to do" (participant 7).

The game-play helped to structure the experience in a manner that visitors could grasp: "The structure of the game, and the experience was an acceptable convention, it was something they understood" (participant 8).

Variety of Interactions

Designers discussed different strategies in the design of interactive artifacts that would result in variety of interactions. In discussing the PDA, the tangibles, and the interactive table, one designer noted: "Each one affords a set of possibilities" and that, "each part was slightly different, but it was kind of integrated with the event that it was meant to be part of" (participant 8). The various technologies that were developed by the design team can be seen in figure 3. In doing so, the variety enabled visitors to make their own decision or construct their own interaction: "You could exercise preference…I like this one better than I like that one" (participant 8).
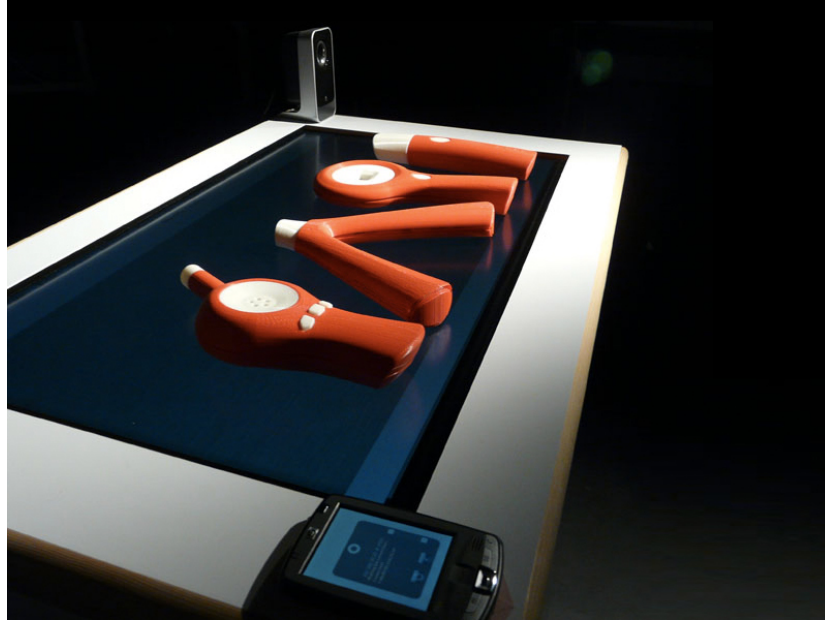
Figure 3: The Kurio tangibles, PDA, application, and interactive table

5.1.1.3: Theme 3: Learning

Learning was also frequently coded from both designers who were interviewed. Statements were coded from two participants with the following frequency: participant 7 (20 statements, 17%), and participant 8 (68 statements, 18%).

Within the interviews, the designers discussed the use of constructivist theory: "We tried to integrate the idea of learning goals, and learning theories as a way to inform the design of our system. The approach we adhered to was constructivism" (participant 8). More specifically, the design of the system "had two complementary models that related to the larger sense of constructivism, but we had a very prescribed Bloom's taxonomy, and it was Kolb's learning cycle" (participant 8). The constructivist models were used to "find peoples' level of challenge, where we weren't giving people information or tasks that were too

easy and we weren't giving people tasks that were too hard" (participant 7). In keeping with constructivist principles, participant 8 notes: "We created a set of resources to construct a learning situation that had to do with something that was part of their everyday construction of reality."

The designers also discussed the form of learning as non-traditional: "Compared to a classroom, I hope at least that it was an environment in which it didn't feel like there were heavy consequences to getting things wrong" (participant 7). Furthermore, designers used "play" to help engage visitors in the learning process. "It didn't look educational on the surface of it, and so I think it fostered a more playful learning style" (participant 7).

5.1.1.4: Theme 4: Designing for Social Interaction

This theme appeared less frequently than others within the interviews. Statements were coded from two participants with the following frequency: participant 7 (11 statements, 9%), and participant 8 (34 statements, 9%).

In the coded statements, designers expressed the aim of designing interactives that foster social interaction between visitors: "Kurio would allow for whole families to interact together, not just with the system, but together as a family" (participant 8). The aim of shared experiences between family members was met by creating resources and situations to allow people to interact and learn from each other:

> "So I think that the best thing that we did about the design…is that we forced people to talk to each other. They had to communicate between the kids when they used the devices to pick them up" (participant 7).

Creating interactions that allowed for conversations to take place that related to the family was seen as valued in terms of creating meaning: "The sole purpose of the tabletop display was the event when the family would get together and try to figure out what was going on" (participant 8).

5.1.1.5: Theme 5: Storytelling

Another less frequent theme was storytelling. Statements were coded from two participants with the following frequency: participant 7 (11 statements, 9%), and participant 8 (14 statements, 4%).

Storytelling was seen as a device to engage museum visitors: "I think it [storytelling] answered the question 'why are we doing this?' I think that, especially kids, like to ask, 'why do I have to do this?' so I think it answered that in a basic way" (participant 7).

Storytelling also helped the designers in establishing "clear goals in terms of learning, and allowed us to create activities that fit with the narrative, but were also learning activities" (participant 8). Storytelling was even seen as a way to shape the interaction or to help visitors make sense of the interaction: "In ways, that I actually didn't think about at first, but realized later, that the narrative actually helped…in some ways it 'narrativized' the system" (participant 8). Finally, storytelling was used to make the experience more "playful" as one of the designers had said during the interview (participant 7).

5.1.1.6: Theme 6: Designing for Different Audiences

This theme is one the least frequently coded from the designers. Statements were coded from two participants with the following frequency: participant 7 (5 statements, 4%), and participant 8 (23 statements, 6%).

This theme manifested from the designers' intention to design for different individuals within the family group. The designers considered the individual's developmental level by employing "individual user models for each of the people who were in the system" (participant 7). "As different family members got better at certain activities, we could scale them through the different levels of Bloom's taxonomy" (participant 8).

The designers also considered the manner in which family members interact, and developed technologies to fit different roles, as one designer stated: "From the beginning you might think that the parent might take the role of the teacher, so the PDA in some ways offered resources… The mom could say, 'I'm going to coordinate everything and you're going to walk around and do one at a time and enter it into the PDA'" (participant 8). The more playful tangible devices were envisioned as being used by the children, that engages both parent and child: "They had to communicate between the kids when they used the devices to pick them up and the parents saw the results of that, and there had to be that back and forth" (participant 7).

5.1.1.7: Theme 7: Emotions

This theme appeared the least frequent of all of the intentions and came mostly from one of the student designers on the team. Statements were coded

from two participants with the following frequency: participant 7 (7 statements, 6%), and participant 8 (1 statement, 0.3%).

The designers intended to create a feeling of comfort for the visitors, in considering the shape of the tangibles: "I think the size of them [tangibles]… it wasn't just about ergonomics, if you think about it, for a child, we made it exaggeratingly large, but enough that it was still comfortable" (participant 8). They also sought to create comfort by limiting frustration while experiencing the museum, as one designer noted: "So if they were taking a long time to do things, we tried to be sensitive to that, and not create frustration by continually assigning them more tasks" (participant 7). Providing a comfortable level of time to experience parts of the activity was not the only aspect related to this, but also the level of difficulty of activities: "I was always trying to find that peak level of challenge, where people would be engaged, but not frustrated" (participant 7).

5.1.1.8: Theme 8: Challenges

Challenges were not interpreted as designer intentions, but rather as aspects that impeded ideas and processes within the design of the system. Statements were coded from two participants with the following frequency: participant 7 (12 statements, 9%), and participant 8 (29 statements, 8%).

Both designers discussed issues surrounding the use of technology, in particular, concerns with overwhelming the user with technology: "from a perspective of a technology designer is that you tend to look at… you don't realize how already complex a museum is" (participant 8). Participant 7's concerns were similar with the use of technology: "One of the things that I kept

thinking about when we were talking about the way in which all these devices

and system were going to work together was whether or not that would be

interfering with [the learning] process" (participant 7). Beyond these concerns

were also the issues surrounding the performance of the system which impacted

other elements within the system: "So a lot of things that we would have liked to

do, to make it prettier, more appealing, or even more educational had to fall by

the wayside to make it work on the basic level" (participant 7). Of the factors

impeding refinement of the user modelling, time was one that was noted several

times within the interviews: "It would have been fun to have more

individualization than we did, but we didn't have time, really, to test the model"

(participant 7).

A second grouping of challenges that was uncovered dealt with the use of

constructivist theory, as participant 8 notes: "We are always running up against

how to formalize when there's no guidelines to formalize it." This is mirrored in

participant 7's comments:

> "I think that constructivist learning was an appropriate path to take,
> it just felt that sometimes that it wasn't giving us enough structure to
> make actual design decisions that would have been easier if there
> was a more rigid framework."

5.1.2: Family Unit of Analysis

From the data collected for this study, eight themes were identified from

the three families that took part in the study. The data on the families is

presented in figure 4, which displays the combined frequency of appearances of

each theme for the family groups within all the data types analyzed. Data from

each family group was tabulated, and appears in the figure as an average in order to better understand the visitor experience across the families. As previously noted, the use of simple statistics is used to provide an overview of the frequency of themes in order to support the qualitative findings, and its intent is not directed at making claims of quantitative significance.

All statements were coded within the family visit data, except for a small number of instances that were inaudible, or trivial statements, such as a family member asking her mother to remove her jacket. These types of statements appeared less than 1% in the in-museum transcripts. Within the self-administered interviews, there was a higher frequency of insignificant statements (25%). These statements involved children responding, "I don't know," to a question; family members laughing; discussing other museum visits without reference to the study; and discussions surrounding how the study was conducted.
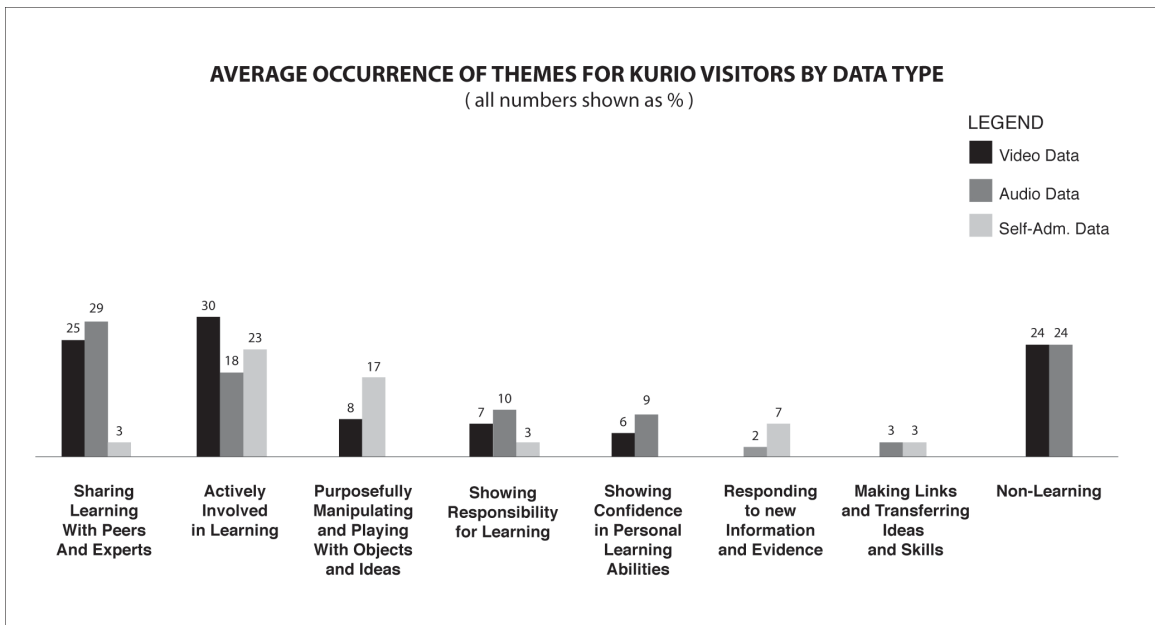
Figure 4: Total occurrences of codes within all data types for the Kurio family groups

5.1.2.1: Theme 1: Sharing Learning with Peers and Experts

Sharing learning with peers and experts was frequently observed throughout the family groups' experience in the museum. Families shared learning through pointing and talking. For example, while at an exhibit about blacksmiths, the mother pointed to various articles on display. While her son used the pointer tangible to select them, the two conversed about the objects they were are looking at:

Mother: What would have the blacksmith made?

Son: Not an anvil.

Mother: No… but they would make like a horse...

Son: Horseshoe… hooks… yeah… (family 13).

Family members were often observed pulling one another to show them information that might be helpful in completing their tasks. For example, in one session, a father says to his son: "Come over here, I want to show you something... you know what you are trying to find… see this" (family 21).

Beyond the museum visit, families reported sharing the learning experience within the self-administered interviews, as one participant noted: "It's pretty fun, it's good to spend a little time with your family… the nice family hub" (family 13).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	13	128	24%
	15	67	24%
	21	162	28%
Audio Observations			
	13	96	24%
	15	89	28%

	21	146	34%
Self-Administered			
	13	2	2%
	15	5	4%
	21	-	-

Table 2: Visitor code frequency for sharing learning with peers and experts

5.1.2.2: Theme 2: Actively Involved in Learning

Families were observed being actively involved in learning through looking at exhibits, information displayed on the Kurio PDA, and on the interactive table. This behaviour exhibited itself as a collaborative activity, where families would often be standing in front of an exhibit, and while the children were looking at the artifacts on display, the mother would be reading from the PDA about the artifacts in front of them. For example, while the children of one family were looking at aboriginal items, searching for an artifact, the mother was reading from the PDA "…so rock carvings, also known as petroglyphs… this rock carving was found at the beach area a thousand years ago" (family 13). The act of collaboratively being involved in learning also showed itself in the self administered interviews where one child from the same family stated: "I like that you have to find things and it would tell you what it was on the monitor" (family 13).

In addition to being actively involved using the tangibles, families would often be observed silently watching the video sequences presented by the system, and also reading their tasks together at the table, exhibiting interest. For example, while at the table, one participant exclaimed: "Cool, I'm in the music industry," after reading her task aloud (family 13).

Another behaviour that was exhibited was the close examination of artifacts out in the museum. For example, after a child had collected an item using the pointer device, the father knelt down beside his daughter to inspect the result of the selection on the PDA screen as he said:

> "It's a wood one right? Elli, this is a block plane… that means that you would move the thing, like that, and it has a little blade, and it would shave off pieces of wood" (family 21).

Family groups also spent on average 13 minutes watching video presentations at the table, which accounts for the difference in coded events between the audio and video data, because video codes were added every 10 seconds, and most of this time was spent silently watching video – events that could not be coded using the audio coding tool.

Data Type	Family ID	Instances	Percentage
Visual Observations			
	13	182	29%
	15	87	31%
	21	194	31%
Audio Observations			
	13	73	18%
	15	50	19%
	21	73	17%
Self-Administered			
	13	20	16%
	15	35	29%
	21	-	-

Table 3: Visitor code frequency for actively involved in learning theme

5.1.2.3: Theme 3: Purposefully Manipulating and Playing with Objects and Ideas

Families were often observed playing with the tangibles with care and interest while searching for artifacts that satisfied the tasks they were assigned by the system. For example, one participant noticed that the artifact she needed

to collect was being blocked by another museum patron, when the museum

patron moved away from the area, the participant eagerly moved to the area,

read the information on display, and then placed the reader tangible over the

area of text that she had just read (family 13). Care and interest using the

tangibles was also observed as a collaborative activity between different

members of the family. For example, while family 21 was standing at a display on

the home, Elli was using the finder device to select an item, after several

unsuccessful attempts, her brother pointed out the area to select in order to help

her achieve her goal, as shown in figure 5.

Figure 5: Family 21 interacting with tangibles and sharing learning

Purposeful interaction with the tangibles was not limited to their use with

children, as adults also used them to uncover information. While observing family

15, the family discussed the answer amongst themselves using the PDA, which

was followed by the mother selecting the object using the pointer (family 15).

Within the self-administered interviews, the tangibles were mentioned on several occasions. One member of family 15 in recalling the experience said: "I remember it was fun. I remember Jen was rushing around. Umm, and I remember all the gadgets…" Not only were the tangibles remembered as part of the experience, they were also expressed as being useful in assisting the learning process, as one child said: "Tools to help you look and learn about other stuff" (family 13).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	13	47	9%
	15	22	8%
	21	47	8%
Self-Administered			
	13	23	18%
	15	18	15%
	21	-	-

Table 4: Visitor code frequency for the purposefully manipulating and playing with objects and ideas theme

5.1.2.4: Theme 4: Showing Responsibility for Learning

In this theme, families exhibited behaviour such as knowing what they wanted to look for and making choices, which was often observed when children had selected an object in the museum and discussed the outcome with the rest of the family. For example, one family was situated in front of an exhibit display, and the mother was using the PDA to read a task to her daughter, after doing so, the daughter understood that the object she had collected was not the object she was seeking, as she exclaimed, "oh, that's not it" (Family 13). This behaviour was later observed in the self-administered interviews where one child recalled the

interactions with the PDA: "You can say that it's the right answer, and you can delete it" (Family 13). Also found within the self-administered interviews was that family members recalled making choices on which exhibits to explore: "Greg and I took turns in deciding where we'd go, and I wanted to go to different areas that he did… but yeah, I think it was pretty good solving the map" (Family 15).

Individuals often showed responsibility for learning by deciding when and where to move. This often occurred when one family member decided to move away from the group to look for specific artifacts or areas of interest. For example, while looking for the forestry area to complete a task, the mother decided to explore the museum for the appropriate area, and spoke to her children: "no, let's go take a look around… hmm… okay… agriculture... oh, here's the forestry…" (family 15).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	13	38	7%
	15	19	7%
	21	36	6%
Audio Observations			
	13	51	13%
	15	40	13%
	21	23	5%
Self-Administered			
	13	2	2%
	15	4	3%
	21	-	-

Table 5: Visitor code frequency for showing responsibility for learning theme

5.1.2.5: Theme 5: Showing Confidence in Personal Learning Abilities

Families showed confidence in their personal learning abilities in several ways. First, children often asked questions of displays while searching for artifacts with the tangibles: "I have a long house… but it says, 'what do you use to cook your food' … so a fire, for heating and cooking, so what do I press?"

(family 13). Another manner in which confidence was shown was through explaining tasks to peers: "Mom, you didn't listen to me… yours is about honey, his is about animals" (family 15). Reading together with peers was also observed, most frequently at the table after being assigned tasks, as shown in figure 6 where the mother is assisting in the deciphering of tasks.

Figure 6: Family 13 reading tasks together at the table

A final behaviour that showed confidence was through comparing information from other sources in the museum, as evident when Tracy talked to her mother and compared an audio sequence she had heard to her assigned task: "It's a mixture of forest and urban parks, it didn't describe how it changed" (family 15).

Despite the appearance of this theme throughout the families while in the museum, it was not observed within the self-administered interview.

Data Type	Family ID	Instances	Percentage
Visual Observations			
	13	17	8%

87

	15	12	4%
	21	30	5%
Audio Observations			
	13	41	10%
	15	22	8%
	21	42	10%
Self-Administered			
	13	0	0%
	15	0	0%
	21	-	-

Table 6: Visitor code frequency for showing confidence in personal learning theme

5.1.2.6: Theme 6: Responding to New Information and Evidence

Families, at times, were observed responding to new information during their visits. Behaviours related to this theme occurred both at the table and in front of exhibits. While at the table and looking at the results of her task on measuring property, one participant said: "Oh, it was the length of land… ahh... oh, I see" (family 15). Evidence of changing views also occurred in front of exhibits through social interaction and using previous experiences to help the child understand the task:

> *Father:* The question is…what item could hold the heated metal…because they have to go in really hot fires. You can't just hold it because your hands would burn off, right?
>
> *Mother:* Remember at the top of the Burnaby Village?
>
> *Son:* Oh, oooh… (family 21).

Evidence of changing views also occurred within the self-administered interviews where one participant in talking about the history of Surrey, notes: "I never knew what it was like back then, it was so weird... but kind of an awesome feeling too" (family 13).

Beyond changing views, both parent and children showed evidence of discovering new ideas. For example, while watching a video sequence at the table, one mother asked her child: "Wow. Did you know that there were that many people in Surrey?", to which her son replied: "ahh, no" (family 15).

Data Type	Family ID	Instances	Percentage
Audio Observations			
	13	9	2%
	15	6	2%
	21	8	2%
Self-Administered			
	13	6	5%
	15	10	8%
	-	-	-

Table 7: Visitor code frequency for responding to new information and evidence

5.1.2.7: Theme 7: Making Links and Transferring Ideas and Skills

Families were observed connecting assigned tasks to their artifacts by making connections between their current task and those assigned earlier. For example, one child, in explaining the artifact that she had just collected said to her mother: "Yeah, that's where I got one the last time" (family 15). Families were also frequently found referring to their assigned questions, as one child explained her decision to select an artifact: "I know… but it said farm animals" (family 15).

Evidence of making links and transferring ideas and skills were also observed within the self-administered interviews, especially with regards to the act of referring to previous knowledge. Within one of the interviews, a child recalls one of her tasks; "…to advertise a pop-star back then, it would be radio, TV, and a record player. That's pretty much the same [as today] except for the record player" (family 13). This act of referring and comparing new information to previous knowledge was not isolated to children, but was also exhibited in

89

statements made by adults in reference to the museum experience: "Hard to imagine it right now, because there is not any logging happening in Surrey right now" (family 13).

Data Type	Family ID	Instances	Percentage
Audio Observations			
	13	25	6%
	15	6	2%
	21	7	2%
Self-Administered			
	13	1	1%
	15	6	4%
	21	-	-

Table 8: Visitor code frequency for making links and transferring ideas and skills theme

5.1.2.8: Theme 8: Non-Learning

Beyond the previous themes that reflect learning, non-learning behaviours were also observed within the family visit sessions. Much of the non-learning behaviours can be attributed to technical issues with the Kurio system, especially at points when the tangibles were non-responsive, or when the application running on the PDA incurred an error. Other instances of non-learning related to discussion of the technology itself, such as when participants would tell each other to press certain buttons on the PDA application or the tangibles in order to proceed with the activity.

5.1.3: Comparing Designer Intentions and Family Visitors

In this section, the intentions discovered through the analysis of the designers will be compared to the outcomes found within the analysis of family

groups. The comparison uses the themes collected on the designer as a starting point for analysis and draws comparison to the family visitor themes.

5.1.3.1: Designing for Personal Experience

This theme connects to all of the visitor themes except for *showing responsibility for learning*. The intention of developing a system where various types of learning resources could help visitors situate new information within their previous knowledge appeared throughout the family visits. One such resource was the role that adults played, as participant 8 describes: "The ability to situate the mother, as coordinator or monitor was a resource". Adults were often found facilitating learning, often using previous experiences to help the child understand new ideas, for example:

Mother: Remember Grandma likes to knit?

Son: Yeah.

Mother: And where does she go to get her Yarn?

Son: At the store.

Mother: Right, she goes to a store… But back in the olden days were there any stores?

Son: No.

Mother: No, so you had to raise sheep, you had to cut the sheep for the wool. You had to spin the wool into yarn. So you are going to look for something that is called the spinner… Do you remember what it looks like? (family 21).

The previous example provides evidence of the relation between the theme of personal experience, and the family theme of both *sharing learning with peers and experts,* and *making links and transferring ideas and skills.*

The tangibles were another resource for learning that were intended to engage the participant's imagination in order to motivate them be *actively involved in learning*. Within the family groups, children were often observed playing with the tangibles in an imaginative manner.

Figure 7: A participant quickly turns around and points at an artifact in a playful manner

As shown in figure 7, a boy in family 13 was observed purposefully pointing at different items within the aboriginal exhibit to collect them, which was followed by a spurt of play where he turned around quickly and pointed it elsewhere, as if the tool was a toy weapon (family 13). The functionality of the pointer was also something that families could relate to from other museum experiences: "…we had our audio unit, we could plug in certain numbers when we were in front of the exhibits… and that was somewhat similar to the pointer idea" (family 15). These two examples demonstrate the relationship between the intention of creating a personal experience and that of *making links and*

transferring ideas and skills, along with the theme of *purposefully manipulating and playing with ideas and objects.*

With regards to the intention of the user model to provide individualized experience, there was no evidence found of participants feeling that the system had done so, or making note that their experience was unique. Additionally, the intention of providing an open-ended experience was in conflict with one participant's experience using the time map: "I think it would have been more fun… if we could have spent more time and gone to each of the exhibits in turn, you know, instead of going to one or the other exhibit and the other option was removed" (family 15).

5.1.3.2: Designing for Play

Through the intentional use of metaphors in the design of the tangibles, the Kurio designers wanted to create an imaginative space and provide a ready understanding of how to operate them. In discussing the listener device, one of the designer states that it "is a cross between a walkie-talkie and a radio" (participant 8). Within the self-administered interview, one participant referred to the listener as, "some telephone thing that you could listen to", which demonstrates the similarity of intent and outcome (family 13).

Another way that designers approached the design for play was through familiar game-play activities, which helped provide flexibility and structure to the experience. At various points during the study participants made note of game-play, such as one family who had just begun looking for artifacts, related the game-play activity to a game familiar to him: "It's just like scavenger hunt" (family

13). Other families commented on the game-play activity within the self-administered interviews: "It's like a game, you have to work together to solve this puzzle" (family 15). Additionally, both families discussed being time-travellers several weeks afterwards within the self-administered interviews: "We had to solve all of the… all those tools, and trying to navigate back to the present", (family 13) and stating that, "it added another element to seeing the museum than just going around" (family 15). These game-play intentions point to the relationship between the theme of *play* and that of *actively involved in learning*.

A final design intention involves the design of interactive artifacts that provide a variety of interactions, which helped the family in actively engaging with the exhibits, or as one designer stated: "Each one affords a set of possibilities" (participant 8). Family members were observed within the museum interacting with the different tangibles, PDA, and the table at various points. One family member noted: "I didn't expect that many ways of looking at things. But that's good, because people, some people are more auditory, some people are more visual, so it covered all of those things" (family 15).

5.1.3.3: Learning

The *learning* theme related to all of the themes within the family visitor analysis, as all of them pertain to learning in some form. The intention of designers within the *learning* theme was to foster learning through providing a set of "resources to construct a learning situation" (participant 8). This intention was realized through numerous examples of the tangibles in use, and the interaction with family members surrounding the artifacts on display. Beyond the museum-

visit observations, participants also noted the use of the tangibles: "…tools to help you look and learn about other stuff" (family 13).

Another intention was to provide tasks that were at the appropriate level of challenge. Though providing a statistical measure of the responses is outside the analysis of this study, it was still possible to gather the auditory responses from the participants on whether they found the task "easy", "just right" or "hard". The majority of the responses that were captured via audio responses were within the "just right" category, with parents often helping the children assess the difficulty level.

A final intention related to learning was to foster a more playful learning style, through designing the system so that it did not appear educational. Various responses were collected that dealt with the playfulness of the system, for example one participant noted that: "I thought it was kind of fun to try and find those things, and make the… pointer light up" (family 15). In doing so, the participant demonstrated the *actively involved in learning* theme, along with the *purposefully manipulating and playing with objects and ideas* theme.

Another participant demonstrated the *making links and transferring ideas* theme in relating the Kurio experience to a more traditional learning museum experience: "It wasn't really a museum and reading every single plaque" (family 13).

Additionally, the intention to design a non-traditional learning environment manifested itself through de-emphasizing the importance of getting the right and wrong answer: "I mean, it's not like getting something wrong prevented them

from learning things… it's not like we failed them" (participant 7). However, one family remarked within the self-administered interview that she "found the map solving a little bit confusing 'cause when we did get an answer wrong… it seemed to be ignored, and It wasn't stressed enough, the true answer" (family 15).

5.1.3.4: Designing for Social Interaction

This theme relates directly to the family visitor theme *sharing learning with peers and experts*. Designers intended to create resources and situations to allow people to interact and learn from each other, for example, in speaking about the questions that were provided to the visitors, one designer stated: "Some there were clear answers, and others where the answers were not so clear that relied on the family to kind of determine what the answer was" (participant 8). Family 13 demonstrates this activity after one child collects an artifact using the reader and returns to her mother to see the results on the monitor, she then says: "Yeah, it was either that one, because it talked about the Coast Salish, and the other with the cooking… and I'm not sure which one it is" (family 13).

Another intention was that adults "had to communicate between the kids when they used the devices…there had to be that back and forth" (participant 7). The "back and forth" was often observed throughout all the family groups. For example when family 21 was at the blacksmith exhibit, the father was holding the PDA device while his daughter was using the pointer tangible to collect the ladle object, and the following exchange took place:

> *Father:* A ladle… that's what she pointed at right there… but it's not made out of wood now is it?

> *Daughter:* oh… (family 21).

These types of interactions that were fostered relate to the themes of *responding to new information and evidence, sharing learning with peers and experts,* and *actively involved in learning.* Shown below is a series of images taken from the studies that demonstrate social interaction.

Figure 8: Family members sharing learning through social interaction

Another goal of social interaction that was stated by the designers was to encourage the dissemination of new information. This activity is evident in the following exchange in which a mother is trying to explain what a manufactured good is: "…like a tree isn't made, it's a resource… so you're looking for something that is made, for someone else to use, and then they sell it" (family 13). In doing so, the mother also exhibits behaviour that would fall within the *making links and transferring ideas and skills* theme, because she is using an

existing concept that her son would understand in order to help him form an understanding of the new term.

5.1.3.5: Storytelling

Storytelling helped to motivate visitors to participate by providing a purpose for engaging in the various activities. The narrative aspect was most evident in the family observations while they were at the table watching the video narratives, which relates to the *actively involved in learning* family visitor theme.

Also at the table, family members would ask questions about the structure of the narrative in order better understand the structure of the activity, for example one mother asked: "Oooh so these are the ones that we've done… so we want to complete the picture" (family 13). Children would also ask questions about the time map and use it to gauge their progress within the game. Asking questions and explaining to peers was a behaviour that was coded as *showing confidence in personal learning abilities* for the family groups.

Within the self-administered interviews, the children from family 13 made note of the narrative saying: "There was a time map broken and we had to go back to the past and we had to solve clues, and all that, to get our time map fixed… so you could go back to the present" (family 13). Through this example, it is evident that the narrative helped the child structure the goals and activities that were part of the system.

5.1.3.6: Design for Different Audiences

This theme related to the following family visitor themes: *purposefully manipulating and playing with objects and ideas, actively involved in learning, showing confidence in personal learning abilities,* and *sharing learning with peers and experts.* The designers' intention to design the technologies for specific roles was demonstrated in the family observations. Parents were often assigned the PDA and took on a facilitator's role in helping their children complete tasks, while their children used the tangibles to collect artifacts in the museum. One example that fits within both the *actively involved in learning* and the *sharing learning with peers and experts* theme involved the mother using the PDA while trying to help her child find the answer to his task:

> *Mother:* You want your question? [she then reads the question out loud]
>
> *Son:* Okay
>
> *Mother:* Rail logging… so this was before the railway… so we can't.. Why don't you look here, and see if this tells you anything (family 13).

Additionally, within the self-administered interviews, one family stated the importance of clarifying the roles each member was going to be in order to achieve their goal: "That would need to be clarified a bit more amongst the family members… about what everyone's role was going to be" (family 13).

5.1.3.7: Emotions

Two emotions that appeared within the designer interviews were comfort and frustration. The designers spoke of creating the tangibles so that they were

comfortable to hold. Despite this intent, none of the families interviewed made comment about the comfort *or* discomfort of these tangibles.

Additionally, the designers for Kurio wanted to limit frustration by being sensitive to the time the families spent trying to achieve their task and by providing tasks that were neither, too easy or too hard. Within the visitor observation sessions, the system had technical issues, which resulted in some visitors getting frustrated at times, and making it difficult to assess the designers' intentions. For example, one family encountered a problem using the pointer at the blacksmith display, which involved the researchers having to take the device away from one of the children. Shortly after the occurrence, the girl complained of being too hot, and asked her mother to remove her sweater (family 21). Beyond this example, another family member discussed frustrations with the tangibles during the self-administered interviews: "I disliked the point… the pointer was not working during it all" (family 21).

Through this analysis, there was no correspondence for the emotion theme with any of the family visitor theme data that was coded.

5.2: BodyWorks 2 at Science World

The BodyWorks 2 exhibit focuses on issues surrounding the human body, such as reproduction, bone structure, and the purpose of various organs. The exhibit was designed for both young and adult visitors. The exhibit hosts a series of artifacts that can be manipulated, text-based didactics, along with a variety of

interactive technologies, such as traditional screen-based interactives and tangible-based technologies that react to physical manipulation.

The designers of BodyWorks 2 included an exhibit designer (participant 9) and the content designer for exhibitions (participant 10). In the case of BodyWorks 2, the two designers selected for participants in the study were those who were most influential on the project's outcome, in that they made the decisions on the visitor experience. Both designers have been working within their respective areas for many years, with participant 9 having ten years experience in exhibit design, and participant 10 with over 21 years design experience.

5.2.1: Designer Unit of Analysis

From the data collected for this study, eight themes were identified from interviewing two of the designers who helped to develop BodyWorks 2. The themes are presented in figure 9 in order of frequency of appearance.

As in the Kurio case, insignificant statements were extracted from the interview transcripts and were not coded (35% of total statements). The insignificant statements consisted of introductory sentences, replies to misunderstood questions, and personal sentiments about the outcomes. Other insignificant statements included specific details of the content that were too specific to be useful, along with tangential explanations, such one participant's story of Frank Openheimer's founding of the Exploratorium (Participant 10).

AVERAGE OCCURRENCE OF THEMES WITHIN BODYWORKS 2 DESIGNER INTERVIEWS
(all numbers shown as %)

LEGEND
■ Participant 9
■ Participant 10
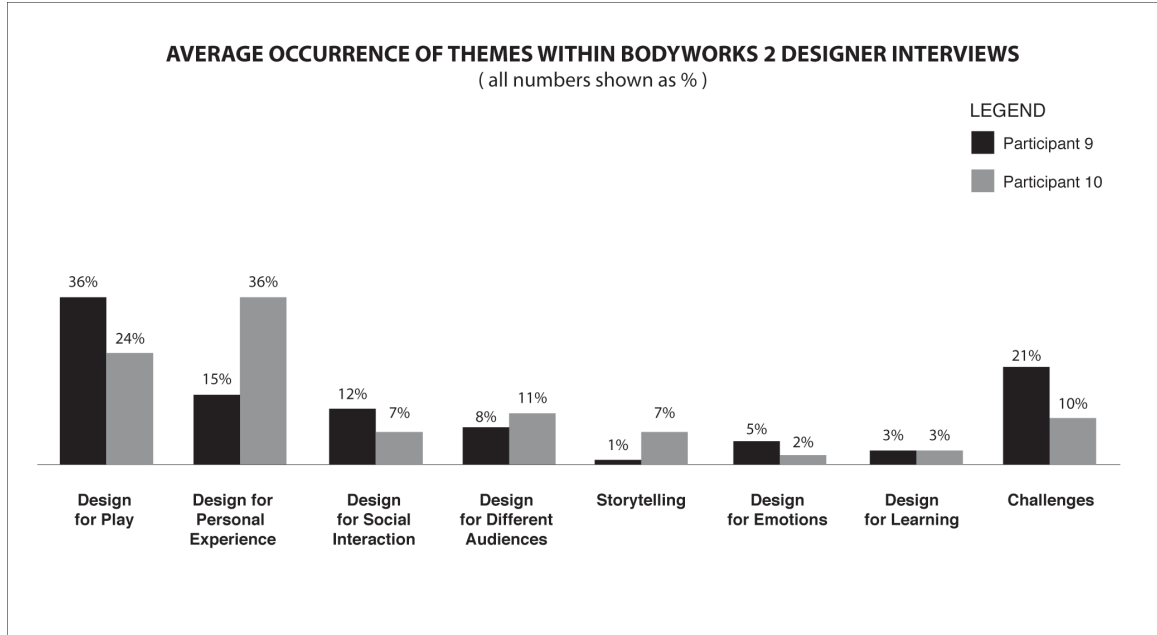
Figure 9: Percentage of coded themes by BodyWorks 2 designer

5.2.1.1: Theme 1: Play

This theme was the most frequently coded amongst the themes. Statements were coded from two participants with the following frequency: participant 9 (112 statements, 36%), and participant 10 (60 statements, 24%). The play theme consists of several sub-themes: *metaphors, designing for imagination, use of game-play,* and *variety of interactions.*

Metaphors

The use of metaphors appeared within the tangible forms of interactives and act as mnemonic devices that help trigger people's memories in ways that are often playful. For example, an interactive that featured a long rope that could be pulled was meant to communicate the length of the human intestine. The

added visceral quality enhances the metaphor and encourages understanding: "But, I do think with the intestine stuff, if it is a literal connection it is a little bit easier for people to understand, not something that you have to know a bit of knowledge about to understand really what this thing is doing" (participant 9). Metaphors provide a ready understanding: "Then you don't have this huge instruction [book]… people are like, 'oh I know' it's just like perfection" (participant 10).

Designing for Imagination

In this sub-theme designers expressed the need to create something new in order to appeal to children's imagination. "We are always trying to create something engaging and something attractive, different than you have seen before" (participant 9). Although innovation is key, using familiar aspects that people can relate to was also important, as one designer noted when speaking about the skeleton interactive: "I like using known game-mechanisms" (participant 10). The expectation of designers was that people are going to try something new but the mechanism for interaction needs to be familiar.

Aesthetics also played a role in fostering imagination. For example, one of the designers knew the importance of aesthetics in sparking children's imagination and fostering engagement with interactives when designing the skeleton puzzle: "We knew we had to use caricatures of the bones, we could not use real bones" (participant 10).

Use of Game-play

Game-play emerged as a way to create and shape engagement. For example, a designer spoke about the aim of designing human reproduction as a game that drew in the visitor: "You choose if you're an 'x' sperm or if you're a 'y' sperm. Then you go through, because you have only so much energy, because that's what sperms do" (participant 10). Game-play requires precision to be matched to the challenge in order to situate someone imaginatively: "Whether it's the digestive game – you could play that independently – you're working a ball through a tract avoiding the pitfalls of acid reflux… and I can just see someone looking at that thing and going 'oh, I had that'" (participant 9).

Variety of Interactions

Designers discussed different strategies in the design of interactive artifacts that would result in variety of interactions. "We wanted all these little interactives that were about looking at something or squeezing something, but we also wanted more text than we ever had in any other galleries" (participant 9). Variety of interactions was important to keep visitors engaged: "We didn't want everything to be a flip panel… we wanted these interactives to go inside the wall so that it kept you engaged" (participant 9).

Providing variety also was important for engaging returning visitors, as one designer notes: "The first time they may have walked around, and remembered the odd piece… when they come back, maybe they would take more time to look at the walls and go through… smaller interactives" (participant 9).

5.2.1.2: Theme 2: Designing for Personal Experience

Designing for personal experience was also frequently coded. Statements were coded from two participants with the following frequency: participant 9 (47 statements, 15%), and participant 10 (94 statements, 36%).

In this theme, the designers wanted to provide the means to make sense of the content by situating it within previous knowledge, or as one designer put it: "And you have to say: how does this fit with your life? So in other terms, what's the relevance here?" (participant 10). Designers spoke of creating design resources that fit people's past experiences and could be used to generate new understandings within the museums.

Focusing on topics that are familiar and personal is seen as a way to create meaning by making personal connections within the museum experience: "So we put all the animals on the scale, and so you can see how much each animal weighs, and see how much your weight reflects the chicken or dog, or where you are in the animal kingdom" (participant 9). A key concern was to take into account previous knowledge as a starting point for enabling people to move from what they already know to something new. The content designer knew the advantages of working with the human body: "I think the thing about the gallery itself is that people can relate to it, because it's about yourself, right? It's about your body and it's something we all have" (participant 9).

5.2.1.3: Theme 3: Designing for Social Interaction

Designing for social interaction was the third most frequently coded theme. Statements were coded from two participants with the following

frequency: participant 9 (36 statements, 12%), and participant 10 (18 statements, 7%).

In the coded statements, designers expressed the aim of designing interactives that foster social interaction between visitors. For example, participant 10 comments on a design that supports this aim: "We have echo monitors, sometimes you can see what other people are doing. That encourages more social interaction, and also that you can just sit right beside them, and you both stare at the same sort of thing" (participant 10). The aim of shared experiences between family members was met by creating resources and situations to allow people to interact and learn from each other. Creating interactions that allowed for conversations to take place that related to the family was seen as valued in terms of creating meaning.

The intention of the designers was also to create competitive as well as cooperative situations that in turn lead to social interaction or to implicitly challenge people to interact. "Well, what we do sometimes in team meetings, when an interactive comes up we discuss how many people will be involved in it, and what kind of experience do we want it to be. And we wanted a great big scale because how many people can get on that thing? I can see a group trying to 'let's try to get up to the elephant weight'" (participant 9).

5.2.1.4: Theme 4:Designing for Different Audiences

This theme was also frequently coded. Statements were coded from two participants with the following frequency: participant 9 (25 statements, 8%), and participant 10 (29 statements, 11%).

Designers wanted to address the needs of different visitor types: "We wanted to be touching upon the elementary school audience, but we wanted the adults to be just as engaged with the exhibits as the kids were… that they could be engaged in different aspects, as opposed to just care-taking for their children" (participant 10). In designing the content, the designers, "wanted subjects that were not only interesting to the kids, but interesting to the parents" (participant 10). The use of different levels also aided social interaction: "Some of the wording or the kind of things involved in it, I think only an adult would know, but I could see a mother saying 'I had an ulcer', and a kid saying 'what's that?'" (participant 9). The use of different levels was also part of the design of the interactives themselves, as participant 10 notes: "Most of the games we chose, I see adults playing with them all the time, so they were not just fun for kids – they were like 'oh, I remember this, I really liked this game'" (participant 10). However, some interactives were designed with a more specific age in mind, as participant 9 notes: "the skeleton game, that's for a fairly young audience, because it's fairly easy to put together, and the skeleton pieces match to the shapes, makes it easy to work through it" (participant 9).

5.2.1.5: Theme 5: Storytelling

The storytelling theme was coded less frequently than the other themes described. Statements were coded from two participants with the following frequency: participant 9 (2 statements, 1%), and participant 10 (19 statements, 7%).

Designers looked to storytelling to guide the design of activities and experience of visitors: "Basically, those questions came out of me drawing up a list of all the great human body exhibits I saw, and then saying 'okay we are going to tell these stories'" (participant 10). The designers were aware that communicating the story required communicating it on different levels: "you can't tell the whole story, right? You can, but on different levels" (participant 9). Storytelling was also a way to determine which design ideas were worthy of pursuit: "We would say: 'that's a good idea' or 'that's not going to work' or 'that doesn't deliver the story very well'" (participant 9).

Storytelling was also seen as a device to engage museum visitors: "I try to think, what are stories that a nine year old might get something out of and an adult might get something out of" (participant 10).

5.2.1.6: Theme 6: Emotions

Emotions are a theme that was infrequently coded. Statements were coded from two participants with the following frequency: participant 9 (13 statements, 5%), and participant 10 (6 statements, 2%).

In constructivism, emotions focus on limiting frustration and increasing curiosity. These two aspects were expressed clearly in our coded statements. For example, designers spoke about creating a familiar and comfortable setting: "'Would you be comfortable if you saw this?', 'would you feel comfortable if you and your family saw this', 'would you feel comfortable if you and your mother saw this?'" (participant 10); or: "Like more inviting, comfortable… so there's places to sit, relax, and take moments" (participant 9).

Fostering the experience further, engendering curiosity was an explicit goal. Simply put, participant 10 states: "We want to inspire, pique people's curiosity about various things." For another designer, "it's like taking that piece and dissecting it, until you figure out which piece that you can make fascinating and manageable to build" (participant 9). Raising curiosity was an explicit goal in the shape and form of design outcomes.

5.2.1.7: Theme 7: Learning

Learning was the least frequently coded theme. Statements were coded from two participants with the following frequency: participant 9 (10 statements, 3%), and participant 10 (9 statements, 3%).

Within the interviews, the designers discussed the use of constructivist theory: "It's this kind of constructivist… I think a lot of people in our industry, lets just say that science centres do" (participant 10). The importance of intrinsic motivation was acknowledged, as one designer states: "I cannot force you to learn, in fact, we don't like the word 'learn' here" (participant 10). The use of other constructivist principles were also mentioned: "It's called Bloom's taxonomy, that gives you higher level of questions like *synthesis* or *application*" (participant 10).

Regarding learning in a non-traditional sense was discussed: "We want to break away from a traditional point of view" (participant 10); and: "It's a different style of learning" (participant 9). Learning was regarded as something hands on, as one of the participant discusses the human anatomy interactive: "It's quite a learning thing – 'don't put the kidney upside-down'" (participant 9), while also acknowledging the role of social interaction in the learning process: "There's stuff

there that young people wouldn't read, there's stuff there that adults would read though, or teach their younger kids" (participant 10). Designers also treated learning outcomes as being long-term: "It's more like, a few weeks later you're like 'remember Science World?'" (participant 10).

5.2.1.8: Theme 8: Challenges

As previously discussed within the section on the Kurio designers, challenges were not considered intentions, but are presented here as they provide insight into the design process. Statements were coded from two participants with the following frequency: participant 9 (65 statements, 21%), and participant 10 (27 statements, 10%).

Throughout the interviews, designers discussed various challenges they faced in creating the exhibit. Certain challenges were encountered from both designers, whereas more particular challenges were based on the role the designer had within the design of the exhibit.

Both designers discussed issues surrounding the use of technology within exhibits, as one designer noted: "They are the hardest things to design for, to make them look good and to incorporate them" (participant 9). However, another designer discussed the importance of technology when he stated: "When we don't use electronics, sometimes it's like 'ooh we're missing something here'" (participant 10). Another challenge that was discussed amongst both the designers were issues surrounding availability of resources such as time, money, and space which effected design decisions: "There is no way in 3000, 5000, 10,000 sq. feet that we can cover every aspect" (participant 10); or: "Because

everything will always come back to 'A', who can build it, how much time do you have, how much money you have, and not everyone can build" (participant 9).

A grouping of challenges related to the development of content was discussed in particular from participant 10: "One was the culling, that was a very difficult thing… We have to worry in an exhibit, what is called 'scope-creep'" (participant 10). A final grouping of challenges, and one that had the highest number of statements, was from participant 9, which involved issues surrounding the visual appearance and construction of interactives: "So it was also a learning curve, to try to build everything so that it could stand alone on the floor, and take a lot of abuse" (participant 9). While having concern for the physical construction is one aspect, the visual appearance is another: "I try really hard to try to come up with something new and not be influenced by something that I have seen all out" (participant 9).

5.2.2: Family Unit of Analysis

From the data collected for this study, 8 themes were identified from the three families that took part in the study. The data on the families is presented in figure 10, which displays the combined frequency of appearances of each theme for the family groups within all the data types analyzed. The simple statistics is used to provide an overview of frequency of themes and to support the qualitative findings, and is not intended to provide quantitative significance. Data from each family group were tabulated and appear in the figure as an average in order to better understand the visitor experience across the families. Within the family visit data, all statements were coded – except for a small number of

instances that were inaudible (less than 1% in the in-museum transcripts). Within the self-administered interviews there were a higher frequency of insignificant statements (21%). These statements involved children responding, "I don't know" to a question; responses that related to other areas in the museum that were visited after the in-museum research session; family members joking with each other; and statements regarding other museum visits in which participants did not relate the experience to the in-museum research session.

AVERAGE OCCURRENCE OF THEMES FOR BODYWORKS VISITORS BY DATA TYPE
(all numbers shown as %)

LEGEND
■ Video Data
■ Audio Data
□ Self-Adm. Data
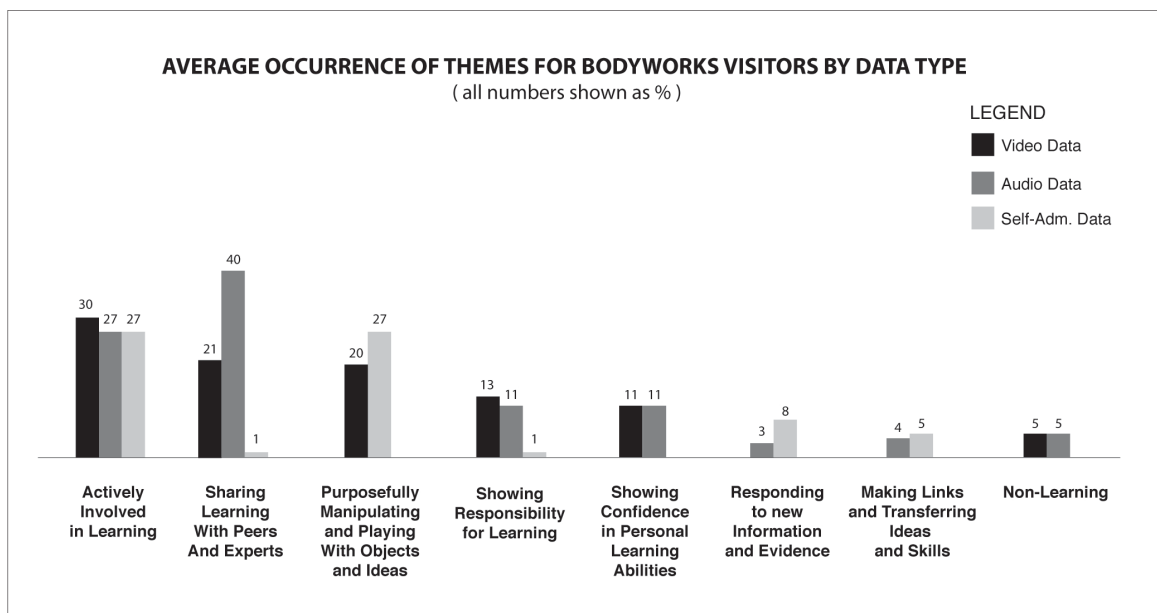
Figure 10: Average occurrence of themes for BodyWorks 2 visitors by data type

5.2.2.1: Theme 1: Actively Involved in Learning

Families were often observed being *actively involved in learning* in various ways, such as through looking at exhibits and reading exhibits. For example, one family while looking at an exhibit on the human body began reading the accompanying didactic: "Look… The average small intestine is a hundred and fifty centimetres long" (family 2).

Beyond reading, families also demonstrated being actively involved in learning through close, concentrated examination of exhibit elements, such as when family 4 were together, interacting with the face symmetry exhibit and talking about the results of their interaction with each other:

> *Mother:* This is the normal face, this is where they took the half and they made them exactly the same on each side.
>
> *Father:* So what they did was that they drew a line down the middle.
>
> *Mother:* …and two left sides.
>
> *Father:* And then, they flipped this over the left fits over this one, and you fit this side beside this one, and you get this.
>
> *Mother:* Now look at her face – it looks totally different
>
> *Father:* Now see, they did this half of her face, and they flipped it over and this is why she has two moles
>
> *Mother:* She also has a wider side of her face, and a thinner side of her face. Wild eh?

The explanation of the exhibit to their daughter was later recalled in the self-administered interview where Rina, their daughter, said: "I remember the one… doing the face thing… where they take a picture of your face, and then they split it in half and do the right side and the left side" (family 4). In figure 11 is a photograph of the family interacting with the exhibit.

Figure 11: Family 4 interacting with the face symmetry interactive

As shown, parents were actively involved in learning along with helping their children better understand concepts and ideas. A final manner in which families demonstrated being actively involved in learning was through curiously engaging with exhibits, as shown when Elizabeth and her mother interacted with the heart drum exhibit:

Elizabeth: Oh, Cool!

Mother: See, when your heart beats slow. See mine beats hard. It's very upbeat. [He proceeds to read] Your heart beats hard over a lifetime 3 billion times.

Elizabeth: Oh, can I see!

Mother: Over 3 billion times! Your heart will beat over 3 billion times (family 5).

The curiosity and engagement described above was also evident within the self-administered interviews where one participant who had also interacted with the heart drum and skeleton interactive noted that she wanted to: "Find out more about the human heart and skeleton" (family 2).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	34	33%
	4	48	30%
	5	45	26%
Audio Observations			
	2	65	28%
	4	100	28%
	5	78	26%
Self-Administered			
	2	12	33%
	4	16	23%
	5	15	25%

Table 9: Visitor code for actively involved in learning

5.2.2.2: Theme 2: Sharing Learning with Peers and Experts

A theme that was frequently observed involved the sharing of learning within family groups. Family groups often talked to each other while interacting with exhibits, often pointing to specific elements to discuss: "Is this one frowning or smiling?", asked the mother, while pointing at a didactic related to facial expressions (family 5). This type of interaction between family members persisted throughout the visit and at times involved the family members pulling others in the group to show them something using the interactives. Such is the case with the family group who were interacting with the hand magnification interactive:

Sharon: Look at that. Mark put your hand the other way around.

Mark: Okay

115

Sharon: Now can I try?

Mark: Your hand is really big.

Sharon: Yeah, and I have nail polish on. Mom, look here. Mamma!
　　　　See you can see the tiny little hair

Mother: That's right. You have tiny hairs. We all do. We have hair
　　　　all over everywhere (family 2).

Within the self-administered interviews, there was little appearance of this theme, however one parent from family 2 did state that it, " is the kind of place that generates a lot of discussion" (family 2).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	15	16%
	4	28	21%
	5	45	27%
Audio Observations			
	2	85	37%
	4	150	42%
	5	117	40%
Self-Administered			
	2	1	3%
	4	0	0%
	5	0	0%

Table 10: Visitor code for sharing learning with peers

Through coding both the visual notes and audio data, a difference of frequency was found, which can be attributed to the longer intervals of time used in taking note of visual observations. Given that audio was coded by statement and that many statements can be made within an interval of 30 seconds, there was an expectation that the results between the two data types would vary.

5.2.2.3: Theme 3: Purposefully Manipulating and Playing with Objects and Ideas

Another theme that was observed involved family members *purposefully manipulating and playing with objects and Ideas*. Collaboration and cooperation

between both adults and children in handling exhibits with care and interest was often observed. For example, one family was seen taking parts of a 3-dimensional puzzle of a human anatomy, with the parents encouraging their children to place various organs into the body cavity, and assisting them when they needed help (family 5). Figure 12 shows an example of the anatomy interactive.

Figure 12: A family actively involved in learning using the anatomy puzzle

When recalling interacting with the same exhibit in the self-administered interviews, a parent within another family group stated: "Doing those things are constructive" (family 4).

While many of the behaviours with the interactives were collaborative, more individually-based interactions also occurred throughout the various family groups, such as when one family member was looking at their hand through an interactive that magnified it, and continued to do so as her family moved on to

another exhibit (family 2). Later, in the self-administered interviews the participant

noted: "What I remember the most was the skin detector" (family 2).

Families were also observed purposefully playing with exhibit elements

that were more hands-on such as at the skeleton bones interactive. The skeleton

bones' interactive is a puzzle that used a timer to challenge participants in

completing it, and was an element that all of the families were observed playing

with. One family in particular played the game a number of times in a

collaborative manner, until they finally were able to assemble the puzzle before

time ran out (family 5).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	19	21%
	4	30	23%
	5	26	15%
Self-Administered			
	2	14	39%
	4	16	23%
	5	11	18%

Table 11: Visitor frequency of theme for purposefully manipulating and playing with objects and ideas theme

5.2.2.4: Theme 4: Showing Responsibility for Learning

Families often showed *responsibility for learning* by making choices on

what to interact with and also making choices while using an interactive. For

example, while interacting with a 3-dimensional anatomy puzzle, a boy talks to

his sister about where the objects should be placed, saying: "This goes here…

and this little thing goes here", while pointing out where the puzzle pieces should

be placed (family 2). Interactives that were smaller and accommodated a single

person often had children asking another group member if they could try. For example, while two parents were interacting with the heart pump interactive, one of their children approached them saying, in a high pitched voice: "Let me see, let me see" (family 5). Another manner in which family members demonstrated a responsibility for learning was through taking pictures of each other interacting with the exhibits, as in family 2 and family 5. Taking pictures of the experience was also discussed within the self-administered interview where the father from family 4 discussed interacting with a face symmetry exhibited and noted: "The only thing I wish I would have done was bring a camera to take pictures of that".

In addition to the aforementioned behaviours, family members showed responsibility towards learning through talking to themselves on several occasions, but most frequently through deciding where and when to move. Families members would generally stay within close proximity to each other, but would often break away from the group to look at nearby exhibit objects, such as when Mark becomes uninterested in the skeleton puzzle, and turned around to read the cartoon (family 2). The provision of different exhibit elements that allow for choice and freedom of movement was also noted in the self-administered interviews, where Mark says: "What I found best about the day was… that there is really a lot to do and you can't really get bored because there are things to do everywhere you go in there" (family 2).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	9	10%
	4	20	15%
	5	22	13%

119

Audio Observations			
	2	22	10%
	4	25	7%
	5	46	16%
Self-Administered			
	2	1	3%
	4	1	1%
	5	0	0%

Table 12: Visitor frequency of theme for showing responsibility for learning

5.2.2.5: Theme 5: Showing Confidence in Personal Learning Abilities

Family members showed *confidence in personal learning abilities* by asking questions of displays and by explaining things to peers. There were numerous occurrences of children asking their parents questions while using interactives, such as when a child from family 4 asks her mother: "What's minimal damage?", after reading information beside the display. Instead of telling her daughter what the term meant, the mother encouraged her daughter to discover the meaning for herself by responding: "You tell me, stick them [her hands] in, and you tell me" (family 4).

Parents were often found explaining information to their children during the museum visit. One family member, for example, had never encountered x-rays before, and her mother provided an explanation of what they are: "They are bones, that's a kind of card. This one's your back, this one is your skull; this is where your eyes go in" (family 5).

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	13	15%
	4	11	8%
	5	19	11%
Audio Observations			

	2	26	11%
	4	47	13%
	5	23	8%
Self-Administered			
	2	0	0%
	4	0	0%
	5	0	0%

Table 13: Visitor frequency of theme for showing confidence in personal learning abilities

Despite various instances of this theme appearing within the museum, no family groups made reference to their experience involving asking questions or explaining to peers within the self-administered interviews

5.2.2.6: Theme 6: Responding to New Information and Evidence

Responding to new information and evidence was one of the least occurring themes coded. Of the instances where these behaviours occurred, families demonstrated evidence of changing views, such as when family 4 was interacting with the 3D anatomy:

Mother: Where's the stomach?

Daughter: Here's the stomach.

Mother: All right, well the stomach is bigger than I thought it was.

This change of view regarding the human anatomy was also confirmed in the self-administered interview where she says: "As an adult, it's always good to go back and refresh your memory on certain things because you forget how big the stomach is or where things fit underneath the diaphragm" (family 4). Similarly, another family had stated within the self-administered interview that: "It was so good to see some misconceptions corrected, because we had thought that it takes more muscles to frown than to smile" (family 5).

121

Another manner in which this theme was observed involved the discovery of new ideas. This type of behaviour often occurred through a parent reading didactic information to their children, or through handling exhibits. One example involved a mother picking up x-ray cards and using them to help explain human bone structure. During this process, the mother tells her daughter: "When you're twenty years old, your bones stop growing", to which her daughter replied surprisingly: "Oh yeah?" (family 5).

Data Type	Family ID	Instances	Percentage
Audio Observations			
	2	10	4%
	4	9	2%
	5	7	2%
Self-Administered			
	2	2	6%
	4	5	7%
	5	6	10%

Table 14: Visitor frequency of theme for responding to new information and evidence

5.2.2.7: Theme 7: Making Links and Transferring Ideas and Skills

Making links and transforming ideas and skills, was a theme found less frequently within the family groups. One manner in which this theme manifested itself was through comparing exhibits. For example, the father from family 5 explains to his daughter how to assemble the 3D human anatomy interactive by comparing it to the skeleton puzzle game: "Remember when we did the puzzle what did we do?" (family 5).

Another way that this theme emerged was through parents referring to previous experiences when explaining things to their children. For example, while

looking at the human anatomy exhibit, the mother from family 2 explains part of the intestine to her child:

"When daddy got ill, the little part that absorbs your food that you see here. Well, when daddy got ill, they were all gone. So all the food in the small intestine wasn't being absorbed" (family 2).

The child would later talk about the human body interactive in the self-administered interview and compare the form in which the interactive took to the actual form of the human body: "I think what they are trying to teach us is how… it looks inside, but not how it really looks, because that would be gross" (family 2).

Adults also facilitated learning through attempting to make connections to new concepts using the child's existing knowledge:

Child: What do bed bugs do?

Father: Bed bugs are just like regular bugs, it's like a mosquito, see that little… [he points to part of the bed bug]

Child: Yeah.

Father: Just like the mosquito has a big one, bed bugs have a small one and it sucks your blood (family 4).

Within the self-administered interviews, families often commented and compared their experience with other museum visits: "Things at this museum that reminded me of the Experience Music Project in Seattle. Remember how you got to play all the different instruments and things?" (family 4).

Data Type	Family ID	Instances	Percentage
Audio Observations			
	2	8	3%

	4	17	5%
	5	11	4%
Self-Administered			
	2	3	8%
	4	9	13%
	5	5	8%

Table 15: Visitor frequency of theme for making links and transferring ideas and skills

5.2.2.8: Theme 8: Non-Learning

A final theme that was observed involved *non-learning* activities. Non-learning occurred while families were waiting for other museum patrons who were using interactives that were of interest, such as the "face aging" machine, and the "face symmetry" interactive. Other instances involved some families playing the bowling game, where little learning was observed. A final grouping of behaviours related to being distracted by adjoining areas and activities within the museum, such as the Eureka exhibit or during science world presentations on the lower floor.

Data Type	Family ID	Instances	Percentage
Visual Observations			
	2	4	4%
	4	2	2%
	5	14	8%
Audio Observations			
	2	14	6%
	4	13	4%
	5	14	5%

Table 16: Visitor frequency of theme for non-learning

5.2.3: Comparing Designer Intentions and Family Visitors

In this section, the intentions discovered through the analysis of the designers are compared to the outcomes found within the analysis of family groups. The comparison uses the themes collected on the designer as a starting point for analysis and draws comparison to the family visitor themes.

5.2.3.1: Designing for Play

The theme *Play* related to various family visitor themes, such as *purposefully manipulating and playing with objects and ideas, actively involved in learning, making links and transferring ideas and skills,* and *showing responsibility for learning*.

First, designers spoke of designing physical objects that could be used as a mnemonic device to trigger memories. By engaging with the physical elements of an interactive, families were often observed being *actively involved in learning* in the museum space, such as with the anatomy puzzle, the heart drum and heart pump, among others.

Figure 13: The heart drum interactive (left) and the heart pump interactive (right)

Within the self-administered interviews, family members used the physical devices to spark their memory: "I remember the skeleton, that we arranged, and the heartbeat, beating like a drum… I remember that it takes the same amount of muscles to frown" (family 5).

The intentional use of metaphors also played a role in helping visitors make connections to new information through actively engaging with the interactives and helping them imagine how their bodies function. For example, while at the heart pump interactive, one family talked about the interactive in relation to their own bodies:

> *Mother:* When you eat and the food you digest, part of it goes into your blood. And then the blood particle goes around your body. And the heart pumps the blood into your body system

> *Child:* Yeah, I know. When you eat the food then it goes around here, it then goes into your blood, then you poo and pee it out.

> *Mother:* Not all of it goes through your heart. It's like a pump, that pumps it around (family 5).

A third design intention that related to play was the designers' use of game mechanics to spark people's imagination, which also provided an affordance for actively engaging in learning. While at the skeleton interactive, which is a puzzle fixed with a timer that counts down and resets the puzzle, the father uses the affordance of the timer to challenge his children at putting the puzzle pieces together when he says: "Ready, set, go", before starting the timer. When he finishes the puzzle, he let's his children try saying: "This is how they do it on the TV show", relating the game-mechanics of the puzzle to something the family had seen on a television show, while also placing the activity within an imaginative context (family 4). The game-play activity fostered a dialogue between the family members, such as the father asking his son: "What's in the middle of bones?", to which the son replied: "Umm… bone marrow" (family 4).

126

A final intention for the designers was to provide a variety of interaction, which related to the theme of *showing responsibility for learning* because it provided the family members with the opportunity to learn about new ideas through making decisions on what they wanted to see. For example, members of family 2 would often wander off to new exhibits and then check-in with each other. For example, when the family was at one of the face interactives, one child left the group to look at the video loop interactive with the video play head – shortly afterwards she became interested in the "skee-ball" game and made her way to that interactive (family 2). These behaviours that were observed, relates to the family visitor theme of *showing responsibility for learning*.

5.2.3.2: Designing for Personal Experience

The designers spoke of making the experience relevant to the visitors through highlighting topics that were familiar to their audience, and presenting the topic as a lens to make meaning from the various interactions in the space. This intention was clearly visible within the 3D human anatomy puzzle, as evident in the following interaction between family members:

Daughter: That's your liver.

Mother: See, that's your kidneys there.

Son: Where's your spleen?... Look at the stomach – it gets real big.

Mother: It's your small intestine.

Daughter: This is your heart.

Mother: This is your heart?

Daughter: Yeah.

Mother: Where do you put it?

Son: Underneath the ribs there, or here (family 2).

The example above demonstrates that the family relates to the content of the interactive, and shows that they've made a personal connection to it by using the term "your". The interchange between family members also demonstrates how the interactive engages visitors in *actively involved learning*, encouraging *sharing learning with peers*, providing the opportunity for children to *show confidence in their personal learning abilities*, through asking questions and *purposefully manipulating and playing with objects and ideas*. Additionally, family members were found interacting with the exhibit and making relations to things within their personal experiences, as previously discussed in the family analysis where the family member spoke of a body organ and relating it to her husband's illness.

Further evidence of intending to make the interactives relevant through the choice of topic is seen in the comparison of the following statements. In speaking about the aging machine's appeal, one of the designers said: "We have this aging thing about getting old, getting wrinkles, and everything like that" (participant 10). The intentional use of aging as a topic helped to create interest in the interactive, such as: "I liked the aging thing, that shows how you will be in 'x' number of years from now. It was interesting to see what your face will look like, in whatever, like 30 years. It was so much fun" (family 5). In addressing the

issue of relevance, the designer fostered the engagement of participants in *active, involved learning*.

5.2.3.3: Design for Social Interaction

Within this theme, designers spoke of designing interactives that encourage social interaction between visitors. The designers achieved this intent through designing resources and situations to foster this type of activity, as is evident in the following example where family members collaborate at the facial expression exhibit:

> *Mother:* Now compare the one on the left to the one on the right…
> let's do it together… this one, look at the mouth. Look at
> the nose, it's pointed.
>
> *Daughter:* This one.
>
> *Mother:* Are you sure?
>
> *Daughter:* No. Flat Nose (family 5).

The interactive that the two participants were using had a large screen that provided ample room for multiple people to crowd around, and also encouraged game-like activity, where families could collaborate on finding the correct answer. In designing the interactive with these affordances, families were observed *sharing information with peers,* being *actively involved in learning*, and at times *showing confidence in personal learning abilities* through asking questions and explaining choices.

Families were also observed collaborating while using more hands-on exhibits, such as the 3D anatomy puzzle, where family members would facilitate the meaning making process by helping to construct the body:

Amber: That's the kidney isn't it?

Ryan: Oh, that's right…

Amber: The kidney goes underneath… and then the stomach is
going to fit in the corner…

Rina: Is that your kidney?

Ryan: That's your liver. I didn't realize it was so high up (family 4).

In the previous example the family exhibited behaviours that fit into several other visitor theme categories, such as: *purposefully manipulating and playing with objects and ideas,* and *responding to new information and evidence.*

Another way that designers fostered social interaction was by intentionally designing artifacts to engage families in competition with one another. As one designer noted:

> "People love to compete. You put a counter on something, that gives them either a score or something else… then people are like 'I did better than you'. You're using a very simple mechanism to encourage social interaction" (participant 10).

The outcome of this type of choice is most evident on the skeleton puzzle, displayed in figure 14, where many families competed against each other to see who could finish the fastest. This was the case with both families 4 and 5, where statements such as: "I almost made it. I was one bone short… Oh, no you can't do that, that's cheating", were observed (family 4). Through engaging this type of

game play, families demonstrated behaviours that fit within the *actively involved in learning* theme.

Figure 14: The skeleton puzzle interactive

5.2.3.4: Design for Different Audiences

In this theme, designers' intended to address different audiences by engaging both adult and children in activities within the museum. They addressed engagement for both audiences through writing content at a level that would encourage adults to explain the content to the children: "I wrote everything as if I was talking to an adult… it could be 'parroted' back to a child", remarked one designer (participant 10). This approach helped to address the themes of *sharing learning with peers and experts* and *making links and transferring ideas and skills.* For example, a family that was looking at the insects display had several questions related to the content, which the father explained using examples from their own lives:

"This is a little bug that lives in the water, and you have to be careful on things like… the deck at aunt Debby's. They don't have the problem because they don't have birds sitting on it. But when you have mites, sometimes, and birds come and sit on it, and then poop on it, then you end up with this kind of

stuff crawling on the wood. So when you climb up, and it goes onto you, then you end up with this itch" (family 4).

Beyond these types of behaviours, both adults and children exhibited behaviours of being *actively involved in learning*. For example, adults and children were often observed at the heart drum interactive, which can accommodate two individuals, and presents their heart rate as the sound of a drum. The following is an excerpt of family 5 at the heart drum interactive:

Elizabeth: Can I do this with you mommy?

Mother: Okay.

Elizabeth: You can't make it go as fast as mine…

Mother: see when your heart beats slow, mine beats hard.

The example above further demonstrates the concept of game play and competition that were previously discussed as intentions, while also demonstrating the family visitor theme of *sharing learning with peers and experts.* The designers intended this type of behaviour, which is evident in the following statement: "For me it's more about… delivering it in a way that appeals to any age" (participant 9). This intention can further be supported within the outcomes as one parent noted in the self-administered interview: "It made me think about the value of attractions like that. Making sure that they have hands on activities, not only for children, but for adults, because that's what sticks in my mind" (family 2).

5.2.3.5: Storytelling

The designers used *storytelling* to help guide the design of activities that the visitors would experience. The importance of stories was apparent when one of the designers said: "The story is the first thing people experience" (participant 10). For the designers at Science World, the intention of the exhibit was to communicate the story of the human body. Through analyzing the family visitor data, particularly the self-administered interviews, participants noted that they understood the main message of the exhibit being, "about how the human body works, and the miracle of the human body. It's intricate beyond most people's understandings…it does a good job in trying to communicate that" (family 2). Similarly, another participant noted that it made them think of, "how beautifully and wonderfully we are made"(family 5). These statements were categorized within the *responding to new information and evidence* theme, as they suggest that the exhibit helped them to view their bodies in a more profound manner.

Using storytelling as a means to engage different aged visitors, and to pique their curiosity was another intention of the designers. Finding evidence of this intention within the family visitors was difficult to find; however, one adult was observed reading a didactic about the use of bones in various cultures: "People in Mexico and Central America would choose to decorate the tombs of ancestors… Wow" (family 2). This example demonstrates not only curiosity on behalf of the visitor, but also of the discovery of something new, which fits within the *actively involved in learning,* and the *responding to new information and*

evidence themes. Children, on the other hand, were rarely observed reading information, and it is unclear how the use of storytelling affected their experience.

As previously discussed, the designers expressed the need to organize the number of stories and present them at different levels, where large bodies of text would be available for those interested. This approach was commented on by one of the adults within the self-administered interviews: "There was this one part in the BodyWorks, where they had the whole big panel with the cartoon... I would have liked to read it. But not when I'm standing there" (family 4). This comment suggests that the intention of placing detailed information on text panels may not be a question of interest in the subject matter, but one of context and placement.

5.2.3.6: Emotions

The designers intention related to this theme concerned the piquing visitor's curiosity, as one designer noted: "I really wanted to pique people's curiosity, so that you might go home and learn more about your body" (participant 10). Interestingly, this intention was evident within the self-administered interview where one parent noted: "It certainly is the kind of place that generates a lot of discussion, and in our case, the children wanted to read about the human body afterwards" (family 2). This statement provided by the visitor helps in drawing a relation between this theme and that of *actively involved in learning,* and *sharing learning with peers and experts.*

Another intention to foster curiosity was to design the exhibits to intrigue visitors, "to continually move through the space" (participant 9). With regards to

the visitor observations, family members often would move independently from one exhibit to another, as previously discussed within the family analysis. Together with providing a variety of interaction, designers would "focus on the key fascinating part" of the interactive to encourage visitors to move around the space (participant 9). In doing so, this intention relates to the family visitor theme of *showing responsibility for learning.*

A second emotion that the designers intended was to foster a feeling of comfort amongst the visitors. Though no family participants specifically commented on issues of comfort, it should be noted that there was little evidence of frustration in the self-administered interviews or within the in-museum observations – except for one visitor feeling that the skeleton interactive was too loud (family 2). Beyond this, all of the families stated that they enjoyed the visit, and had fun on several occasions.

5.2.3.7: Learning

In the final theme, *learning*, the designers intended to create a constructivist learning environment where learning would be both hands on and social. There are numerous occurrences of visitors learning in this manner, which have been previously discussed, such as the families collaborating at the human anatomy puzzle, learning about their heart rates at the heart drum interactive, or discovering facial composition at the face symmetry exhibit. The intention of approaching learning in this way relates to the visitor theme of *sharing learning with peers and experts*, *actively involved in learning*, and *purposefully manipulating and playing with objects and ideas*.

Another intention that the designers had in relation to learning was that they approached it with the understanding that it is something that occurs over a longer period of time, and not something that is based on rote memory (participant 10). Within the self-administered interviews, which occurred 2-4 weeks after the initial visit, various families showed evidence of changed views, along with demonstrating the discovery of new ideas: "I would tell people that it takes the same amount of muscles to frown as it does to smile. So many people tend to get that wrong. I would like to share that in order to clarify that misconception" (family 5).

A final intention surrounding learning was that it should be self-motivated, and the designers placed importance on the ability of individuals to make their own choices on where to go and what to learn. As previously discussed in this chapter, family members were often observed making decisions on where and when to move, a behaviour that is linked to the *showing responsibility for learning* visitor theme.

5.4: Conclusion

This chapter has focused on the description of both case sites – Kurio at the Surrey museum, and BodyWorks 2 at Science World. Within both cases, two unit of analysis were discussed and their data compared to one another. A number of themes were uncovered through the designer interview data, which points to designers, in both cases, intending to stimulate a personal experience with visitors, designing interactives with the affordance for play, while stating concerns to create an experience that allowed for social interaction between

group members. Other themes were uncovered in the data, to a lesser degree, including the use of storytelling to help visitors make sense of the experience, designing interactives on different levels to help visitors of different ages to interact with exhibits, the consideration of the emotional affect of the experience, and concerns with the learning outcome of the experience. A more detailed comparison of the designer intentions from both cases will ensue in the following chapter, in which the findings from each theme will be addressed.

With regards to the family visitor data that was collected, the analysis has shown that certain themes appeared more frequently than others, such as *sharing learning with peers and experts, actively involved in learning,* and *purposefully manipulating and playing with ideas and objects.* Participants in both cases were often found talking to one another about the exhibits, showing interest in the content of the exhibits, and using the interactives associated with the exhibits to help make sense of what they were looking at. In the Kurio case, it was shown that a higher number of instances related to non-learning activities – which was attributed to technological issues with the interactive system. Themes that were found in lesser frequency, in both cases, included *showing responsibility for learning*, *responding to new information, making links and transferring ideas*, and *showing confidence in learning abilities*. The analysis of both cases demonstrates various points of similarities within the observed groups, and a more detailed comparison of cases will be presented in the following chapter.

Through presenting intentions and outcomes in both cases, a relationship was drawn between the two units of analyses. This chapter demonstrated this relationship through the comparison of designer statements and the data collected on the visitor groups. In each case, the designer themes were related to the visitor-based themes, and examples of these relationships were provided to highlight the correspondence. It was found that the themes uncovered through the designer interviews related to multiple visitor-based themes, for example, designing for social interaction related to the theme of *sharing information with peers and experts, actively involved in learning*, and *showing confidence in personal learning abilities*. In both the Kurio and BodyWorks 2 cases, the results highlight the notion that certain design intentions impacts a variety of aspects of a museum visitor's experience, and the themes used to understand the visitor's experience are not mutually exclusive. In the following chapter, the relationship between intentions and outcomes will be discussed with regards to both cases in order provide the reader with a synthesis of this study's results, with the aim of addressing this study's research questions.

CHAPTER 6: FINDINGS

This chapter relates the findings from both cases to the research questions presented in chapter 4. Based on a description of both case sites, analysis revealed patterns of design intentions that were presented as themes. These themes will be discussed in section 6.1 to address the first research question: *How are constructivist intentions expressed by designers?* In section 6.2, the outcome of the comparison of intentions to outcomes will be presented in order to answer the second research question: *Is there a relationship between intentions and outcomes?* This will be followed by a summary of the chapter in section 6.3.

6.1: Expression of Constructivist Intentions

According to the case study investigation, seven design intention themes or patterns were discovered. Themes that were found in similar frequencies across both cases will be discussed, followed by the themes that were found to have different frequencies. Each theme will be described in relation to the similarities and differences with regards to how the intentions manifested themselves as design decisions

Of the seven themes, *design for play* and *design for personal experience* were found in high proportion in both cases, followed by *design for social interaction*. A theme that appeared less frequently within the interviews was

storytelling. The least commonly expressed theme was design for *emotions*. In terms of differences in frequency, a noticeable difference was found within the theme *learning,* which appeared more often in Kurio than in BodyWorks 2. Another difference in frequency between the cases was the *designing for different audience* theme, which appeared more frequently within the BodyWorks 2 designer statements.

To describe how designers expressed constructivist goals, each theme will be presented in detail with similarities and differences, in relation to the findings of previous research.

6.1.1: Design for Personal Experience

Together with *design for play*, this theme was among the most frequently found pattern. In the interviews, designers from both cases stressed the importance of considering the visitors' previous knowledge when designing the exhibit elements. This finding corresponds to previous constructivist research, where the importance in providing people with conceptual access is stressed (Hein 1998). Within both cases, the designers wanted to create design resources that were familiar to their audiences; for example, the Kurio tangible devices used metaphors to help communicate their function, or within BodyWorks 2 where the designers used common game-mechanics to help people understand how to use the interactives. Additionally, in both cases the designers wanted to create an open-ended experience, where the visitor determines what they want to see. Freedom and openness have been noted in previous research to help people find enjoyment in learning (Duffy and Savery 1994).

Designers also sought to provide a personal experience by addressing the notion of conceptual access, however, they approached this intention in different ways. Within BodyWorks 2, the designers sought topics that were general and that their audience could relate to. The Kurio designers took a different approach by focusing on providing specific individual content and challenges honed to their level of conceptual development. In doing so, the designers intended to address conceptual access by providing tasks that were at a level that the age group could understand based on the task previously completed and their level of education.

6.1.2: Design for Play

Play was another theme that appeared in high frequency across both cases and was used as a device to engage visitors. Play is an important aspect within constructivist theory as it helps to engage and challenge people to achieving greater levels of understanding (Piaget 1969, Vygotsky 1978). Within this study, the manner by which the designers from both cases expressed the use of play was similar across all of the sub-themes.

In the two cases, designers were found using metaphors for hands-on interactives to help communicate functionality and make it more playful in appearance. Addressing visitors' imagination was also evident by the careful choices in shaping the interactives. The approach that designers from both cases used was to create a novel form – something that visitors had never seen before – but similar to objects they knew, which acted as a point of reference. For example, the reader tool in Kurio looked similar to a magnifying glass, but it was

larger, had a toy-like appearance and didn't actually magnify things. However, the shape did provide some affordance on how to hold it and use it based on one's previous knowledge of a magnifying glass, but the overall device was something new.

Game-play was also used by both design teams as a way to encourage and structure visitor engagement. Focus was placed on the use of game-mechanisms that were familiar to the audience that they had most likely previously encountered. For example, BodyWorks 2 makes use of puzzles, while Kurio used a game similar to that of scavenger hunt, as one family visitor had noted in the observation sessions.

A final way that designers in both cases aimed to create a playful experience was by providing a *variety of ways to interact* with the exhibit content. Within constructivist research, providing information using different modalities is helpful in addressing different styles of learning and provides a choice to allow people to experience the exhibit in a manner most comfortable to them (Hein 1998). In both cases the designers wanted to provide a variety of interactives to offer choice to the visitor and to keep them engaged. Additionally, designers from both cases discussed the importance of different kinds of interactions that the exhibits would facilitate, such as reading, physical manipulation, and socializing.

6.1.3: Design for Social Interaction

Social interaction is part of the development process for human thought in constructivism. Hein explains that social interaction helps people increase their own learning by sharing the experience with others (Hein 1998). Social

interaction was discussed in both cases in similar ways. The designers wanted to create situations that would encourage social interaction; such as the design of an event in Kurio where adults would talk to their children about the artifact that their child collected; or in BodyWorks 2, where textual information was written at a level that would engage adults to share the information with their children.

Social interaction in the form of collaboration and cooperation was also encouraged through the design of hands-on exhibit elements. In both cases, interactives were designed with consideration of space, size, and context. Also, many of the interactives were comprised of objects that were designed for families to engage with together. In Kurio, for example, families could crowd around the table to watch videos together on a large surface, but could also share the PDA screen while out in the museum to help them communicate task-related information. Similarly in BodyWorks 2, the designers created large exhibits with the affordance for groups of people to crowd around, such as the human anatomy exhibit.

Another approach to encourage social interaction, present only in BodyWorks 2, was the desire to engage visitors in competition with each other. Providing individuals with challenges and the opportunity to gain confidence in activities is an important aspect in constructivism (Vygotsky 1978). The designers attempted to create competition by using score-based game-play activities, or through "timer" mechanisms that encourage people to compare their abilities and challenge one another.

6.1.4: Storytelling

Storytelling in constructivism is part of the interpretive process and used to help structure reality. Designers found storytelling to be a technique for cohesion and sense making in their design of interactive artifacts.

In both cases, the designers used stories as a way to guide the design process, as it provided a clear goal to work towards, and a means to think about activities that would support the narrative. For example, the time-traveller narrative within Kurio was used to structure the activity of collecting artifacts by positioning it not as a goal within itself, but as an activity that supported an imaginative goal of fixing the time-map. Similarly, in BodyWorks 2, the story of the cardiovascular system helped in structuring activities that supported the communication of the heart – which took the form of the heart drum and heart pump interactives. Despite these similarities, the relation of the narratives to the content differed; within Kurio, the narrative was a fictitious element whose goal was an imaginary one, which was different from the learning goal of communicating the history of Surrey. In BodyWorks 2, the narrative was realistic, and its goal was coupled with the learning goal – the story of the human body.

6.1.5: Emotions

In constructivism, *emotions* focus on creating a comfortable environment (with limited frustration) that fosters curiosity in order to motivate individuals to learn (Hein 1998).

Within the two cases, the designers rarely discussed the use of emotions, which resulted in this theme being the least frequently coded. The designers in

both cases expressed the desire to create a comfortable experience by considering the shape of the interactives and by using the appropriate display content for the amount of time family groups would spend at each exhibit. For example in Kurio, the designers focused on the size of the tangibles to be comfortable for children, while also developing a system that would provide more or less tasks to the family, based on time.

Curiosity was an emotion that did not appear in the Kurio interviews, but was present in the BodyWorks 2 exhibit interviews. The designers attempted to pique people's curiosity by considering the subject of interest, or story, and breaking it down until a fascinating aspect emerges that could be feasibly constructed. An example that demonstrates this is the intestine interactive, which was conceived as a long rope that visitors could pull out in order to communicate the interesting facet of the intestine – its length.

6.1.6: Learning

Learning was an intention that was expressed infrequently within the BodyWorks 2 design interviews and appeared more frequently than in the Kurio interviews. This difference in frequency can be explained by the BodyWorks 2 designers' perspective on learning, as one designer stated: "In fact, we don't like the word 'learn' here, because, yeah, you can do the pre-visit, post-visit things, but at best you're going to get rote memory" (participant 10). The statement implies that learning is something of interest, but that they approach it in a different manner than traditional learning institutions. For the BodyWorks 2 designers, learning may be considered an implicit goal, impacted by the

145

institution, enacted by the designers, and consequently, the usage of the term "learning" was rarely found within the designer interviews. In comparing these findings to the Kurio case, learning was an explicit goal, with designers often speaking of issues that related to learning, and the difficulties in assessing it within a constructivist context. For the Kurio designers, learning was a requirement that involved a certain level of unfamiliarity, and consequently, the design process involved a phase where research was conducted on learning approaches in museums. Within BodyWorks 2, both of the designers had over ten years experience, which provides the time and experience to internalize strategies to facilitate learning. These differences between the cases may provide an account for the frequency difference.

Despite the difference in frequency between the two cases, the qualitative findings were similar with regards to their design intentions. Both cases showed evidence of treating learning as a self-motivated activity that enabled the visitor to uncover things of interest, as one designer from Kurio noted: " You weren't searching for specific information, you were just searching for information, and really it could be any information you were interested in" (participant 9). This finding coincides with constructivist principles where learning is viewed as an intrinsic, self-regulated activity based on the individual's interests and curiosity (Vygotsky 1978, Piaget 1969, Bares et al 1998).

Constructivist learning was approached through using similar tools, such as Bloom's Taxonomy to address different stages of learning and cognitive development. Within Kurio, the designers employed the learning tool to help

structure tasks on different levels. In BodyWorks 2, the designer expressed the use of Bloom's Taxonomy, but did not describe how it was employed.

Another intention that was shared amongst the designers was that the museum experience was designed to be aesthetically different than traditional learning activities. The designers in Kurio expressed this intent through using game-like activities and through the playful design of the tangibles. Similarly, one of the designers for BodyWorks 2 expressed the desire to work with a professional game company in order to produce interactive learning games that did not look educational.

Beyond these similarities, the designers from both cases expressed that learning should be addressed as a long-term process, rather than focused on short-term outcomes focused on rote-memory. This finding suggests that current forms of learning evaluation should consider different approaches to measuring learning that takes place over greater lengths of time, and places greater focus on how the experience was appropriated into the visitors' everyday life. Additionally, learning can be understood as a goal that was expressed through the other design intentions themes, many of them being found in similar frequencies.

6.1.7: Designing for Different Audiences

Another characteristic of constructivism is to consider the exhibits appeal, accessibility, and meaning to a wide range of visitors by considering the visitor's

developmental level (Hein 1997). By interviewing the designers in both cases, we uncovered similar findings.

In both cases, the designers sought to position the adult or parent in the group as a facilitator for their child's learning, though they took different steps to achieve the goal. The Kurio designers used a technological approach to position the parent as a facilitator in their child's learning. In the BodyWorks 2 case, the designers also positioned the parent as a facilitator, but through a content-orientated approach. By designing the content to be more adult-orientated, using subjects that would be engaging for both young and old audiences, the designers sought to create situations where the parent would share such information with their children. This approach is also found in constructivist exhibit design, where exhibits should address both children and adult audiences, rather than be designed for a specific age group (Hein 1997).

A separate approach to address different audiences was found in the Kurio design interviews that relates to constructivist research. This is to consider various stages of intellectual development and create challenges aimed at an individual's zone of proximal development (Hein 1997). The Kurio designers used this principle to address the design for different individuals within the group by employing a user model to assign tasks that were at an appropriate level of challenge.

6.1.8: Summary

This section presented the findings regarding the expressed intentions of the designers from each of the cases in order to address the question: *How are constructivist intentions expressed by designers?* By presenting the intentions as themes comprised of design patterns, eight themes were discussed including: *design for personal experience, design for play, design for social interaction, storytelling, emotions, designing for different audiences,* and *learning*

Design for personal experience involves designers considering a user's previous knowledge when designing interactives by shaping them to be more familiar to the visitor, and thinking of the interactives as resources towards an open-ended user experience. *Design for play* involved designing resources for interaction with an affordance for game-play, while also providing a variety of ways to interact with the technologies, and designing their visual appearance to encourage participants to use their imagination. *Design for social interaction* showed designers concern for in-group interaction by designing resources to accommodate more than one participant at a time, and using mechanisms to encourage competition between group members. The previous three themes were found to be the most frequent across both cases, which point to their importance in the application of constructivist principles

The *storytelling* theme emerged as a method to aid designers to structure the visitor experience; however the two cases used stories in different ways. The designers for Kurio used a narrative that was fictitious towards an imaginary goal that differed from the learning goal, whereas the BodyWorks 2 designers used

more realistic narratives toward a goal that was coupled with the learning goal. A theme of lesser frequency was *emotion,* in which the designers sought to appeal to the emotional sensibilities of the visitors through their concern of visitor comfort and curiosity. *Design for different audiences* involved the design of resources to position adults as facilitators for their children's learning, though the cases took different approaches to achieve the goal. The designers for Kurio took a technological approach by assigning more complex technologies to parents, whereas the designers for BodyWorks 2 created resources that would require parents to explain complex concepts to their children.

The final theme, *learning,* appeared in different frequencies in both cases, but the manner of its application was similar. Through the analysis of cases, the learning theme can be seen as being expressed through the other themes, which points to the notion that these design intentions are not completely independent, but overlap at various points. For example, the theme *design for personal experience* interacts with the theme of *design for play* in addressing resources that appeal to a user's imagination, because designers need to consider a visitor's previous experience to provide an aspect that is both familiar, while also designing the interactive to be both playful and new. Another example of interaction between themes is seen in the *design for social interaction*, *design for play, design for different audiences,* and *learning,* where designers intended to create an experience that was social by providing game mechanisms that encourage playful dialogue between peers, while at the same time shaping the technologies and content on different levels to help position the parent as a

facilitator in their child's learning. These examples demonstrate that the themes uncovered in this study are not completely separate entities, but relate to each other in a variety of ways towards providing a holistic constructivist experience.

6.2: The Relationship Between Intentions and Outcomes

This section presents the findings of the comparison of intentions and outcomes from the two case sites in order to answer the second research question: *What is the relationship between design intentions and their outcomes?* By comparing the results from each case the various intentions were found to correspond to the experience that was observed in the family visits. The similarities and differences will be discussed, and the design intention patterns will be related to the constructivist assessment themes in order to explain their potential usefulness to future design practice.

6.2.1: Design for Personal Experience

The intentions surrounding the *design for personal experience* corresponded to behaviours that fell within the following assessment themes: *making links and transferring ideas and skills*, *actively involved in learning, purposefully manipulating and playing with ideas and objects,* and *sharing knowledge with peers and experts*.

The intentions surrounding the provision of resources that were familiar to the visitor afforded conceptual access, which in turn, helped visitors make connections to previous knowledge and experiences, a behaviour that is considered in the *making links and transferring ideas and skills* theme. Several

resources were considered within both cases, including the family members, the technologies, and the exhibit content. In BodyWorks 2, the designers used topics that were meant to be relevant to their visitors, such as the body, the heart, and aging, which fostered personal interest in the exhibit that lead to participants engaging with the content – a behaviour that relates to the *actively involved in learning* theme. The technologies that were developed within each case were also designed to provide conceptual access by employing metaphors that visitors could relate to, such as the appearance of the tangible devices in Kurio. The use of this principle in the design of the technologies helped visitors understand how to use the hands-on exhibits to experiment and learn about the exhibit content, behaviours that fit the *purposefully manipulating and playing with objects and ideas* theme.

Through the careful consideration of technologies and content, the designers were able to position the family members as resources to further enable learning in a personal way. In both cases, the designers understood the role of family members in facilitating learning and created situations where the sharing of knowledge could occur, such as a facial expression interactive that used the user's face as content, which was also large enough to allow groups to crowd around. These situations facilitated discussions that often involved comparisons of the phenomenon with a previously shared experience. The behaviours that resulted from the aforementioned interaction often related to those within the *sharing learning with peers and experts* and the *making links and transferring ideas and skills* themes.

6.2.2: Design for Play

The intentions surrounding the *play* theme contain sub-themes, which will be related to the observed visitor behaviours in order to demonstrate the correspondence of designer intentions to their outcomes.

6.2.2.1: Metaphors and Imagination

The use of *metaphors* to help guide the shape and aesthetic of the interactives produced behaviours that related to visitors *purposefully manipulating and playing with objects and ideas*, as previously discussed. They also helped produce behaviours that are included in the *actively involved in learning*, and *making links and transferring ideas and skills* themes.

Metaphors provided a conceptual bridge for participants to relate the novel and playful forms of the interactives to more familiar objects, which not only helped them understand how to use them, but also inspired the visitors' imagination. Evidence of this appeared in the family visits where children were observed playing with the technologies in unanticipated ways, as was the case with the Kurio tangibles. In BodyWorks 2, metaphors were used to couple the interactivity with the content of the exhibit, such as the use of a hand pump that was used to communicate the pumping of the human heart. While using interactives that employed this principle, participants were observed using previous knowledge to imagine the phenomenon within their own bodies. In both case sites, the interactives fostered behaviours that belong to the *making links and transferring ideas and skills* themes. The coupling of function and content further aided visitors of BodyWorks 2 to be *actively involved in learning* as the

interaction that was required was directly related to the content. Whereas in Kurio, the interaction was a means to discover new information, unrelated to the form of the interaction. The effect of this difference was observed within the self-administered interviews where children from the BodyWorks 2 case talked about the phenomenon encountered in the museum through the use of the interactives. Whereas in Kurio, the use of the tangibles were discussed separately from the content they encountered in the museum.

6.2.2.2: Game-Play

The use of game-play activities within both cases, engaged visitors in behaviours that relate to the following assessment themes: *actively involved in learning*, *making links and transferring ideas and skills*, and *sharing learning with peers and experts*.

The use of game-play in the cases produced similar behaviours amongst the visitors by employing mechanisms that were familiar and understandable, such as puzzles, quizzes, and scavenger-hunt type games, which visitors were overheard comparing to games they had previously played. This behaviour of making comparisons to previous experiences relates to the theme of *making links and transferring ideas and skills.* The familiarity with these types of mechanisms afforded a ready understanding and playfulness that engaged visitors in the museum content. In both cases, families were observed engaging with these types of interactives in a collaborative; and in the case of the BodyWorks 2, a competitive manner, which was often accompanied with family members talking to one another. Through talking about the interactives, and

engaging with them together, the sub-theme of game-play relates to the assessment themes of *sharing learning with peers and experts* and *actively involved in learning*.

The use of game-play also produced non-learning behaviours, especially when the game activities were weakly coupled to the content of interest. This was especially evident at the skee-ball game, where families would throw balls in an arcade-like manner at symbols of insects. Though families displayed engagement by playing the game and laughing, there was little discussion that related to learning. This phenomenon occurred within Kurio, where children would be observed, at times, playing with the tangibles and not focusing on their assigned task, especially when the adult holding the PDA was engaged with another child.

6.2.2.3: Variety of Interactions

By providing a variety of ways to interact with exhibits, the designers in both cases fostered behaviours that are related to the assessment themes of *showing responsibility for learning, purposefully manipulating and playing with objects and ideas,* and *actively involved in learning*.

The provision of different kinds of hands-on technologies and text-based information created opportunities for individual family members to make decisions on what they wanted to see and do next – which relates to the theme of *showing responsibility for learning.* In both cases the experience was designed to be open-ended; families could wander through the space for things of interest. The variety of interactives encouraged movement and choice by offering ways to

explore the museum content. In both of the cases, families were observed using hands-on interactives, reading, and looking at video displays – behaviours that relate to the theme of *actively involved in learning* and *purposefully manipulating and playing with objects and ideas.*

6.2.3: Design for Social Interaction

This theme was related to behaviours found in: *sharing learning with peers and experts*, *showing confidence in personal learning abilities* along with *making links and transferring ideas and skills*, and *responding to new information and evidence*.

The designers' intention to foster social interaction succeeded, as is evident with the high frequency of the *sharing learning with peers and experts* theme within the family visit analysis, along with the qualitative analysis. This was accomplished by creating situations such as the event where children collected artifacts and shared them with peers via the PDA in Kurio, or during the manipulation of large, multi-person hands-on exhibits in BodyWorks 2.

Through the aforementioned social interactions, adults would often respond to their children's questions, sometimes explaining more complex information that arose through reading or interacting with exhibits, which would result in children learning something new. These behaviours relate to the *showing confidence in personal learning abilities* and the *responding to new information and evidence* themes. In BodyWorks 2, the designers expressed that they had written content to foster this type of interaction between parent and

child. Whereas in Kurio, this often emerged through the exposure to existing museum content that was facilitated by the system. Additionally, social interaction together with the personal experience intentions provided situations that positioned parents as facilitators in their child's learning, which emerged in the form of adults explaining ideas using experiences that their child had previously encountered. In this way, social interaction provided an avenue into the *making links and transferring ideas and skills* theme.

Within Kurio, social interaction was designed to foster collaborative interactions with peers, whereas in BodyWorks 2, the designers expressed the desire to engage families in both cooperative and competitive interactions. At the exhibits that used counters and timers, competitive behaviour did emerge among the family visitors, which provided both playful, game-like, discussions, along with opportunities to share learning regarding the content of the actual interactive.

6.2.4: Storytelling

Storytelling is a technique that was used by the designers in both cases to guide design decisions and to help structure the visitor experience. By comparing the intentions to the outcomes in both cases, a difference emerged, which points to the importance of coupling the narrative goal with a learning outcome in order to achieve behaviours related to the theme of *responding to new information and evidence*.

In both cases, storytelling afforded the visitors a way to think about the visit in a holistic manner. When families discussed the experience within the self-

administered interviews, they made reference to the intended narrative. For the BodyWorks 2 designers, the intended narrative was the story of the human body, which all groups grasped, based on their interview statements. Within the Kurio case, children felt that the main message was to reconstruct the Kurio time-map and return to the future, which was the goal of the narrative, but not the intended learning outcome. The disconnect may be attributed to the weak relation between the learning outcome and the narrative goal. In BodyWorks 2, the two goals are tightly coupled, whereas in Kurio, this is not the case. Based on the analysis of the BodyWorks 2 visitors, participants not only understood the central idea of the narrative, but also commented on how their perception of their bodies changed, which relates to the theme *responding to new ideas and evidence*. In Kurio, visitors commented on being engaged in activities that related to the narrative, often in detail, but they did not exhibit any changes in viewpoint that can be attributed to the narrative.

6.2.5: Emotions

The designers' intentions to address the family visit on an emotional level by addressing comfort and curiosity was met with mixed results. The desire to pique curiosity was an intention found solely within the BodyWorks 2 interviews, which resulted in behaviours that belonged to the theme of *actively involved in learning,* and *sharing learning with peers and experts*. Through the use of broad topics that the audience could relate to on a personal level, along with presenting fascinating aspects of those topics, visitors were observed reading and pulling other family members to show them parts of the exhibits that were of interest.

The desire to provide a feeling of comfort to visitors was an emotion that was discussed in both cases. Though the results from both family visits provided evidence that they enjoyed the experience, direct evidence of comfort did not emerge. More so, within the Kurio case, there were moments and statements that were heard that pointed to visitor frustration, which can be attributed to the technical issues with the system that were encountered – which limited interaction and prolonged the family visits. Beyond this, the assessment tool used to measure the family visit experience did not address the issue of comfort, an issue that impacts the comparison of intention to their outcomes.

6.2.6: Learning

The intention to provide a non-traditional learning environment where *learning* is perceived as long term and self-motivated, was shared amongst the designers in both cases. The assessment tools used in the study considered these constructivist concepts in that they focused on how people learn, not what they remembered, along with assessing the learning outcome beyond the museum visit. As shown in the previous chapter, people learned in various ways, but most frequently through *sharing learning with peers,* being *actively involved in learning*, and through *playful manipulation of objects and ideas*.

In trying to create a non-traditional learning environment, the designers aimed to infuse playfulness and hands-on interaction, which focused on making the experience appear less educational. Visitors in both cases were frequently observed collaboratively using interactives, and comments within the self-administered interviews cite the use of the hands-on aspect of the experience as

being fun. Evidence of long-term learning was also found within the two cases where visitors commented on the benefit of hands-on exhibits to help them learn, the family discussions that arose through the experience, and the impact of the experience on how they think about the topics they encountered.

Providing an environment that fosters self-motivated learning was another common intention amongst the designers, which resulted in the design of resources that provided variety in their design and could be appropriated by visitors to help them make meaning from the experience. In doing so, the design provided the opportunity for visitors to make decisions, and seek information that was of interest to them. This resulted in families exhibiting behaviours that related to the *showing responsibility for learning* through deciding where and when to move, and making choices on what to interact with. Limiting choice produced dissatisfaction, such as at the Kurio time-map where one family commented that they would have liked to explore all of the areas, rather than having to choose one or the other.

6.2.7: Designing for Different Audiences

The designers in both cases considered their audience in the design of their respective experiences, which related to behaviours that coincided within the following themes: *sharing learning with peers and experts, actively involved in learning* and *showing confidence in personal learning abilities*.

In both cases, the designers sought to position the adult or parent in the group as a facilitator for their child's learning; one case approached this through

technological means, the other through the thoughtful design of the content. Both

cases resulted in parental behaviours that related to the designers' intentions.

For example, adults within the Kurio case were often observed using the PDA

device to help organize the family group, reading information to their children

using the device, and also using it to show their children their progress. Within

BodyWorks 2, there were numerous examples of adults facilitating learning in

similar ways, through reading text associated with exhibits, and explaining

aspects that related to the interactives they were using.

As previously discussed within the Kurio family analysis, the designers

also employed a technological approach to assigning tasks to individual family

members on levels that were developmentally appropriate. The results of this

approach are beyond the means to assess in this study, and the results of which

can be found within a paper written with other researchers who were part of the

Kurio project (Hatala et al 2009).

6.2.8: Summary

This section presented the findings from the comparison of design

intentions to the outcomes experienced by family groups, in order to address the

second question of this study: *Is there a relationship between intentions and*

outcomes? The findings demonstrate that a number of the intentions of the

designer relate to the outcome experienced by family groups. The intentions

categorized as themes were described in this section and related to the visitor

behaviour themes, with many of the themes finding points of similarity between

the two. Overall, learning is shown to be an implicit goal within the other design

intentions, in that design intentions that fell into other themes also incorporated the intention of fostering visitor learning. The *emotions* theme showed the least strongest relation, as the designers' attempts to create a comfortable environment did not necessarily result in the participants' outcome, and in the case of Kurio, some visitors expressed frustration, especially with regards to technological issues. In order to provide an overview of the findings from this section, table 17 is used to demonstrate the relationship between intentions and outcomes in this study. The table provides the reader with the design intention themes, the design actions that relate to the intentions, the outcomes experienced by visitors, and their associated theme. The table also demonstrates that the design intentions themes interact with each other to produce outcomes that span multiple visitor behaviour themes, which further suggests that the themes work towards creating a holistic experience, and are not independent elements that can be removed without affecting the outcome as a whole.

Design Intention Theme(s)	Design Actions	Outcome	Related Visitor Behaviour Theme
Design for Personal Experience *And* Learning	• Using topics that are broad and that the individual can relate to	• Engagement with content of interactive • Relating the content to previous experiences • Talking to others about the relationship between content and previous experience.	• Making links and transferring ideas and skills • Actively involved in learning • Sharing learning with peers and experts
Design for Personal Experience *And* Design for Play	• Using familiar game mechanisms and metaphors in the shaping of the form of interactives to improve the conceptual access of interactives.	• Participants could readily engage with interactive with little or no instruction. • Participants related the interaction mechanism to their previous knowledge / experiences.	• Making links and transferring ideas and skills • Actively involved in learning

Design for Play *And* Learning	• Coupling metaphor used in an interactive with the subject of the content. (e.g. The hand pump interactive that mimics a heart pumping)	• Affords the opportunity for participants to better imagine the phenomenon in question while interacting with the artifact. • Places focus on the subject of the interactive rather than the form. • Weak coupling of metaphor results in non-learning activities (only play)	• Purposefully manipulating and playing with ideas and objects • Making links and transferring ideas and skills • Actively involved in learning
Design for Play *And* Design for Different Audiences *And* Learning	• Creating a variety of interactives of different types and sizes	• Provides the user with freedom to choose what interests him/her • Encourages self-motivated learning through exploration of different ideas • Provides different modalities to interact that addresses various senses • Larger interactives provide for collaborative between individuals	• Purposefully manipulating and playing with ideas and objects • Actively involved in learning • Showing responsibility for learning • Sharing learning with peers and experts
Design for Social Interaction *And* Learning	• Creating interactive situations that provoke conversations. (e.g. The monitor tool in Kurio / The human anatomy in BodyWorks 2)	• Results in participants talking to each other about the content • Participants asking questions and explaining things to peers	• Sharing learning with peers and experts • Showing confidence in personal learning abilities • Responding to new information and evidence
Design for Social Interaction *And* Design for Different Audiences *And* Design for Personal Experience *And* Learning	• Writing content aimed at different levels of proximal development while making the subject familiar to the participant	• Adult becomes facilitator for children, and often explains difficult concepts using previous experiences that are familiar with child. • Adult is plays active role through reading to peers.	• Sharing learning with peers and experts • Showing confidence in personal learning abilities • Responding to new information and evidence • Making links and transferring ideas and skills • Actively involved in learning

Design for Social Interaction *And* Design for Play	• Designing interactives that afford multiple people to interact • Using game-mechanisms that use timers and keeps score.	• Fostered collaboration, cooperation and competition between peers • Opportunities for discussion of content during manipulation of interactive elements	• Sharing learning with peers and experts • Actively involved in learning • Purposefully manipulating and playing with ideas and objects
Storytelling *And* Design for Play *And* Learning	• Using a narrative to frame the use of interactives • Coupling the narrative's goal to the learning outcome of the experience	• Provided an avenue to recall the visit. • Where coupling of narrative goal and learning outcome occurred, participants were found to remember visit in a more holistic way that resulted in changed perceptions.	• Responding to new information and evidence
Emotions *And* Design for Personal Experience *And* Learning	• Using topics that are familiar to visitors and designing interactives around the fascinating aspects of such content.	• Participants were often observed pulling their peers to see artifacts and interactives of interest to them.	• Actively involved in learning • Sharing learning with peers and experts
Learning *And* Design for Play	• Care towards the aesthetic of the interactives being non-educational in appearance.	• Participants expressed having fun, and what they had learned through interacting with the technologies.	• Sharing learning with Peers and experts • Actively involved in learning • Purposefully manipulating and playing with objects and ideas

Table 17: The design intention themes and their corresponding behaviors

6.3: Conclusion

This chapter presented the findings from the analysis of both the Kurio

and BodyWorks 2 cases and positioned them in terms of the first two research

questions of this study. In doing so, this study has described a series of design

intention patterns concerning the use of constructivism within the area of

experience design. Additionally, the study has described the relationship

between the various design intentions and the outcomes they produced within

family visits. The design intention themes presented in this chapter begin to draw

an outline of a constructivist framework for describing constructivist interaction

design, which will be discussed in the following chapter.

CHAPTER 7: DISCUSSION

The aim of this chapter is to discuss the findings presented in the previous chapter and position them within the larger field of interaction design. First, in section 7.1, the findings will be discussed in terms of their implications for design practice. This will be followed by section 7.2, where the findings will be addressed with regards to their implication for design research. Afterwards, in section 7.3, the study's limitations will be presented, and the chapter will conclude with a summary in section 7.4

7.1: Implications for Interaction Design Practice

In this section, the findings will be discussed in terms of their contribution to interaction design practice. The findings are useful to interaction design practice in three ways. First, the study's results contribute to existing works where constructivism has been applied to interaction design, while also extending the use of such principles outside of traditional learning environments. Secondly, the resulting themes uncovered in this study begin to draw an outline of a constructivist framework for describing and assessing interaction design. Thirdly, the themes also provide insights to address the shortcomings within the phenomenological approach to user experience design.

7.1.1: Contributing to Previous Constructivist Interaction Design Practices

The findings from this study contribute to the existing research in interaction design where constructivist principles have been employed in practice. One such context that this research directly contributes to is that of museums and museum learning technologies

In recent years museum staff have increasingly adopted constructivist principles in the design of exhibits; however, little research has explored how these principles are employed in the shaping of interactives, nor has previous work explored the correspondence of the principles with their outcome as experienced by visitors. For example, Hein provides a variety of principles to help guide the design of exhibits, but they lack the specificity to enable designers to understand how to make use of them – especially within an interaction design context. Within the semi-structured interviews that were conducted, designers spoke of the difficulties in applying existing principles, as there was no clear example to base design decisions on. Through this research study, many of the principles that Hein discusses become evident in practice within the designer interviews, providing future museum designers an understanding of how they might employ constructivist principles in practice. In doing so, this study acts as a bridge between theory and practice, as it demonstrates how museum designers interpret constructivist principles to form intentions and organizes these intentions into patterns that interaction designers can use to help them in creating constructivist exhibits. More so, by investigating the relationship between design intentions and their outcomes, exhibit designers can better understand how their

design actions will impact various aspects of a constructivist experience within a museum.

Beyond the museum, the findings from this study contribute to existing research in the area of constructivist learning technologies. As learning technologies have been increasingly a subject of investigation in the field of HCI, people have adopted constructivist principles to help guide their design. This research relates to existing approaches, such as the use of game-play, narrative, and multiple senses to engage participants – as seen in the Savannah project (Naismith el al 2004). This research contributes by helping to situate these design choices within a larger design pattern. For example, the use of game-play was shown to play a role within the larger theme of *design for play*, while the use of multiple senses relates to the theme of *design for different audiences*, when used together, they can provide a learning experience that affords social interaction, engagement with exhibit content, and conceptual access to a wider variety of visitors. The findings also contribute to existing models that have been employed such as Zurita and Nussbaum's model for handhelds in constructivist learning environments (2004). The authors' model shares similarities with the findings from this study; however, they provide less guidance for designers. For example, the authors' model includes the principle of collaboration, which is shared with the *design for social interaction* theme uncovered in this study; however, there is a lack of detail provided by the researchers on how to employ the principles. By providing detailed qualitative findings on how to employ these

constructivist principles, this study may prove to be useful to future interaction design practice in the area of constructivist learning technologies.

Additionally, previous studies that have used constructivist principles have neglected to use a constructivist evaluation strategy, opting instead to use more traditional HCI methods of evaluation, which make it difficult to draw relationships between the use of constructivist principles and their outcomes. This exploratory investigation makes it possible to begin to understand how certain constructivist intentions relate to specific aspects of a constructivist experience. This is useful not only to help designers understand what a possible outcome may be when employing constructivism, but is also helpful to researchers who seek to develop a more comprehensive model for constructivist learning technologies, where particular design actions can be analyzed more thoroughly.

Finally, the study contributes to current work within interaction design in non-traditional learning contexts, as museums are commonly considered non-traditional learning spaces. In previous works that applied constructivist principles there was often difficulty in extracting guidelines to aid designers in the development of these systems. For example, in the design of a virtual environment tool, Winterbottom et al. describe distilling constructivist principles into a set of values that the designers would refer to when making design decisions (2008). These values were akin to guiding concepts, rather than being prescriptive design guidelines. Constructivist principles were also referred to in the GeoNotes (Persson et al. 2001) and the Affective Diary projects (Lidstrom 2006), but often in terms of broad concepts, such as open-endedness or

considering the user's previous experience. Despite these being important

constructivist principles, they do not provide design practice with usable

guidelines, nor do they attempt to provide an over-arching framework for applying

constructivist concepts within interaction design. In this study, the findings point

towards providing design examples of how to employ constructivist principles

through the various themes described, while also moving towards the

development of a framework to address various aspects of a constructivist

experience by highlighting the interrelation of themes and revealing how they

impact various aspects of the visitor experience. For example, in applying the

patterns *design for social interaction* and *design for play*, a designer might

choose to create a large interactive to provide the affordance for collaboration

and cooperation, while also using mechanisms to encourage the interaction

between peers, such as the use of a timer. In applying these principles, which

are derivatives of the themes that this study has presented, the designer could

expect that the resulting outcome of interaction, from a participant's perspective,

would involve an increased level of physical interaction with the artifact that

would be accompanied by related discussions about the content of the

interactive.

7.1.2: Towards a Constructivist Interaction Design Framework

The themes presented in this study begin to draw an outline of a

constructivist framework for describing and assessing interaction design. The

themes and sub-themes detail and mobilize the principles of constructivism in

terms of interaction design. An underlying assumption is that the themes

constitute an analytical description of user experience and it is possible to see how the dimensions of constructivism, expressed here as themes, can articulate the design of user experience. By interviewing designers from each case, it became clear that there were difficulties in applying constructivist principles found in the existing literature, due to the lack of specificity with regards to how particular concepts should take shape in the designed artifact. Additionally, designers spoke of the difficulty in assessing their designs, as an assessment tool for constructivist interaction design is yet to exist. In light of these shortcomings, this study's exploration begins to approach an understanding of a constructivist framework, in that it describes a series of high level concepts, or themes, details how these themes can be employed in terms of interaction design, and relates these actions to outcomes that can be assessed using an evaluation tool. These efforts should be viewed as contributions to an emerging understanding of a constructivist framework for interaction design, rather than a framework in itself, and consequently the researcher makes no claims to one in this research.

Moving towards a constructivist interaction design framework would require future research in further refining the themes, along with the assessment tool that was employed in this study. The assessment tool used was designed specifically for museums, with emphasis on the visitor's experience, especially with regards to learning. In order to address other contexts, where learning is de-emphasized, but a constructivist experience is desired, an adjustment to the current assessment tool would be required. For example, the category *sharing*

learning with peers could de-emphasize the learning aspect – yet still retain the central quality of collaboration and cooperation between peers. Other categories may be simpler to incorporate into a more general assessment tool, such as *purposefully manipulating and playing with objects and ideas*, whereas other themes may pose greater difficulties in modifying. Despite this challenge, the value of the assessment tool is its focus on describing aspects that are important within a constructivist experience, such as being actively engaged, socialization, and self-motivation. Indeed, work towards a more general assessment tool remains an open question, but one that this research hopes to inspire future designers to take up.

7.1.3: Addressing the User Experience

Central to this study is the consideration of the user experience, as discussed in chapter 2. Research in the area of user experience has blossomed in recent years, with a variety of perspectives emerging from different disciplinary backgrounds. One such approach, phenomenological, involves characteristics that relate to several of the themes uncovered in this study and will be discussed below.

Phenomenology shares a number of philosophical underpinnings with constructivism as they base their approach on a cognitive, or mentalist view of reality, but have their origins in different disciplines (LeCompte & Schensul 1999). Chiari and Nuzzo provide further evidence of this connection:

> "…these approaches share a view of knowledge (and truth) as interpretation, an interpretation historically founded rather than

timeless, contextually verifiable rather than universally valid, and linguistically generated and socially negotiated rather than cognitively and individually produced" (Chiari & Nuzzo 1996).

Given this connection, it is not surprising that the themes that were uncovered in this study relate to existing research within the phenomenological user experience approach. First, the phenomenological approaches argue for a holistic and qualitative study of user experience (Mahlke 2008), which is mirrored in the results of this study, as the themes cannot be considered as independent of each other, but rather, they interrelate with each other to the point of interdependence. For example, the theme of *design for play* involves the use of metaphors and game-play, which is reliant on the themes of design for *social interaction* and *design for personal experience.* In this way, the findings are not reduced to a series of components that can be separated to achieve different effects, but instead interact with one another to achieve experiences that fall into multiple categories of assessment.

Secondly, existing phenomenological frameworks, such as Forlizzi and Ford's, propose that designers trying to create an experience can only design situations, rather than predicted outcomes – a finding that was also found within both cases when interviewing the designers (2000). Designers, when interviewed, spoke of learning as open-ended, something that could not be forced, nor predicted, and that design actions focused on the creation of resources that visitors could choose to appropriate in the creation of a personal learning experience. Other aspects within Forlizzi's and Ford's framework that are similar to the findings in this study involve the appreciation of *personal*

experiences, *emotions*, along with the structural aspects of *storytelling*, three

themes that were uncovered through the designer interviews (2000).

Furthermore, Battarbee (2003) adapts the aforementioned framework to include

the concept of co-experience, experiences constructed through social interaction,

which relates to the theme of *design for social interaction*, uncovered in this

research study.

Within another framework, McCarthy and Wright (2004) discuss the

importance of narrative to provide structure and composition for an experience,

which was similarly found as s strategy within this study. The authors also refer

to emotions as an important component of their framework, another point of

similarity with this study's findings. McCarthy and Wright (2004) along with

Sengers et al. (2004) argue that designing for experience requires the

acknowledgement that the actor is actively involved in the creation of their

experiences through a process of interpretation, and that designed artifacts

should provide support for flexible interpretations. These qualities were also

found within the designer interviews and relate to the findings that fall within the

themes of the *design for personal experience*.

Despite the various similarities between the findings of this study and

existing phenomenology approaches to user experience, there are also

differences that should be noted. Forlizzi and Ford's framework for example, act

as a lens to understand different kinds of experiences for consideration in design,

rather than guidelines for design. In this manner, the categories of their

framework are expressed as different types of experiences that should be

supported in design, such as experiences that exist on a sub-conscious level, cognitive experiences, and also experiences that are relived through storytelling. McCarthy and Wright's (2004) framework differs from this study's findings in that it involves the consideration of space and time as factors that are important in the design for experience. Though space and time were discussed within the designer interviews in both cases, they presented themselves as aspects within different themes. For example, the concern for space had an impact within the *design for social interaction* theme, in that the size and space around interactives helped to shape the possibility of interaction between visitors.

This brief comparison between this study's findings and existing approaches to experience design from a phenomenological approach highlights many commonalities. Continued research may lead to a refinement of these approaches into a more comprehensive framework, however this endeavour is beyond the scope of this study. The merging of phenomenology with a constructivist approach would also benefit those seeking an evaluation tool for the assessment of experience, which is currently lacking in the field, and to which this study can additionally contribute.

7.2: Implications for Interaction Design Research

In this section, the findings will be discussed in terms of their contribution to interaction design research. In section 7.2.1, constructivism is presented as an emerging design epistemology that challenges existing HCI and interaction design viewpoints. Then, in section 7.2.2, the findings of this research will be shown to contribute to existing research on designers and their activities.

7.2.1: Constructivism as an Emerging Design Epistemology

A designer's epistemological stance influences the design goals'
outcomes and possibilities. While seemingly obvious, the underlying views of
designers typically go unstated and unexamined. The challenge in understanding
constructivism in interaction design is that current epistemological viewpoints
cannot support a constructivist understanding. Symptomatic of this is that the
various constructivist projects that were discussed in chapter 2 did not employ
constructivist-oriented assessments. In this section, we discuss two existing
viewpoints, *instrumental* and *axiomatic*, as a contrast to exploring constructivism
as a present but yet unarticulated design orientation.

The first epistemology can be described as *instrumental.* This is a familiar
view of interaction design and HCI that shapes design through human tasks and
explicit goals. Interactive technology is a means to supporting definable tasks
and can be measured by needs and requirements that are extrapolated from the
stated goals. Within this orientation, values of efficiency, reliability, and usability
are not only epistemological themes but also measurable factors that can lead to
quantification and experimental methods of assessment. While at times this view
is strongly critiqued, it maintains a baseline or essential position in interaction
design and is often expressed as functionality – an essential if not sufficient
quality of any interaction design artifact.

The second epistemology can be describes as *axiomatic*. In many
respects this view relates to the previous view in that it is often discussed as user
experience improvements to functionality; for example, increasing the user-

friendliness of a design or improving upon its usability. However, its assumptions are distinct. It is considered axiomatic in that design artifacts are seen as stand-alone entities describable and measurable by principles and universal traits. The notion of affordances is a good example of this view. A design affordance is a principle that is transferable to any artifact. Transferable traits are seen to be intrinsic or can be made intrinsic to the artifacts dependent on universal human traits but little else. This view holds sway in many design disciplines resulting in critical attention to the form and function of objects and built structures. In interaction design and HCI, the axiomatic view relies on user satisfaction, user preferences, and usability testing for assessment.

Constructivism as an epistemological viewpoint holds many differences with prior views. Constructivism views design through experience rather than tasks. Goals are seen to be multiple and unstated and in most cases constructed through interaction and perception rather than prior. Constructivism speaks to the multiplicity of experience and the process by which individuals (interacting with others and the world around them) construct their experience without universal traits and principle attributes of artifacts. Constructivism focuses on process and the self-construction of knowledge. In this sense, nothing can be stand alone or independent of this process. In this research study, designers talked about designs as resources that become final in the development of thought on the part of the user. The critical distinction in constructivism is that experience and its construction are central. The very idea of user experience is not an independent and measurable phenomenon but rather the process of human consciousness.

This process does have traits as our themes show but the descriptions speak to the dynamics of making experience. In this exploration of a constructivist orientation for design, it is possible to see constructivism's advantage in addressing the holistic, subjective, and dynamic qualities of user experience. Further, as is suspected, constructivism is a common if not unarticulated orientation for many interaction designers.

7.2.2: Contributions to the Study of Designers and their Activities

In addition to the proposal of constructivism as an emerging design epistemology, the study itself contributes to the existing research on designers and their activities. Nigel Cross, in discussing design research, explains that there are three areas that should be explored to better understand design knowledge, including: people, processes and products (2006). Design knowledge exists firstly in people, in the human ability to design, including how people design, associated behaviours, and how this knowledge may benefit future design education. Secondly, design knowledge resides in processes, "in the tactics and strategies of designing" (Cross 2006). Cross states that a major area of design research is methodology, which includes the study of design processes, and the creation and application of techniques that support designers. A third source of design knowledge is in the products that are created by designers. Cross explains that products embody design attributes in the forms and materials that were chosen by designers, which is knowledge that can be used by others to help shape future artifacts (2006).

The methodology used in this research study focuses on all three of the sources for design knowledge, which serves as an example for future researchers within the field of design research. By focusing on designer intentions and goals, this study addresses the need to understand design knowledge that exists within people. Though the semi-structured interview methods are common within the field, the purpose of the interview – to uncover design intentions – is currently underexplored, especially with regards the design of museum technologies. The findings from this research study also contribute to the understanding of design processes, specifically with regards to how designers employ constructivist goals in the shaping of interactive technologies. Existing knowledge on the subject of constructivism often point to principles which are divorced from the design process, whereas this study focuses on how these principles take shape, in two separate cases, which highlight common techniques that may serve purposeful to the design of future research studies in this area. Beyond focusing on people and processes as sources of design knowledge, this study also contributes to the study of design knowledge that resides in products, in that it focuses on interactive technologies and the experiences they support. This study's adaptation of an assessment tool from a discipline outside of traditional understandings of design serves as an example for how tools from outside of the field of design can contribute to design knowledge.

Beyond addressing the aforementioned three sources of design knowledge, the study of design goals and their corresponding outcome is one

that has been rarely explored in previous research, not to mention constructivist interaction design. It is often the case that the design of artifacts is followed by a period of evaluation, which affords designers an opportunity to reflect upon how their goals were realized or where they fell short. The knowledge gained through this process may be recorded in an ad-hoc manner, and is often internalized, serving to benefit the individual's implicit design knowledge. Rarely is this process rigorously documented and explored for the purpose of sharing the insights with the wider research community. In doing so, this research contributes methodological insights into how to explore the relationship between design goals and their outcomes within the field of interaction design.

7.3: Limitations

There are limitations inherent to the choice of cases in this study. The museum setting makes it hard to separate out implicit learning goals typically assumed within museums. Cases in different settings such as offices or homes may have different results. Some readers may question the applicability of exhibit design or the role of content to interaction design. Yet, we feel that a museum setting brings to the fore-front user experience and the interactions between people, artifacts, and surroundings – all of which are highly critical to interaction design. Also, the deliberate choice of cases that were deemed constructivist presents itself as a limitation to this study's generalization to other types of sites, but due to the nature of the study, this limitation was unavoidable.

Additionally, there are limitations within the design of the study. In terms of methodology, the Kurio case visitor study was captured using video, which was

later coded, whereas within the Science World visitor studies, visual observation notes were recorded, then later coded. This was because permission was not granted to videotape the sessions at Science World. The impact of this difference was discussed within the analysis chapter of this thesis, and may contribute to the difference in frequencies of specific themes appearing more within audio recordings than within the visual observations. Since this study took a non-comparative approach, the difference in data collection methods between the two cases plays a lesser role. Also, the study was limited to capturing behaviours that fit within the existing MARVEL themes, which proved difficult in capturing behaviours relating to emotions and reflection, which are important aspects to a constructivist perspective.

A final limitation pertains to the case-study approach taken to understand the topic of investigation. In many respects, this study's approach is both descriptive and exploratory, which are inherently limited to theoretical generalizations, as opposed to statistical generalizations that speak to populations. Having noted this limitation, this qualitative study provides useful knowledge to the area of design research and exposes new ground for future research endeavours.

7.4: Summary

This chapter focused on the contributions of this study to both design practice and design research. The contributions to design practice addressed benefits towards the field of museum studies, with the focus on improving the use of constructivism within that field – but also discussed the emergence of a

constructivist framework that may benefit the field of interaction design, along with aiding current understandings of the user experience. The discussion then moved towards the contributions to design research, where constructivism was proposed as an emerging design epistemology, and the contribution of the study towards the study of design knowledge was highlighted.

CHAPTER 8: CONCLUSION

User experience, or UX as it has become known in the field, has emerged as a term used to describe issues of usability as they pertain to an individual's use of a particular interactive technology. Initially conceived as an additional qualitative aspect to accompany instrumental measures, such as a system's efficiency and effectiveness, it has since become a topic of its own that shifts the focus of study from the interactive artifact to the individual's personal needs. This shift is mirrored in the development of interactive technologies, which have progressed from complicated computer systems, used by experts, and into the everyday lives of those living in the Western world. Despite this shift, the design and evaluation of interactive systems continues to be approached using techniques aimed at instrumental details, while often regarding subjective responses of visitors as being of lesser importance. Since experience is arguably a phenomenon that is inherently subjective, the continued application of existing approaches in the fields of HCI and interaction design is troublesome. It is clear that new approaches to understanding and evaluating the user experience are needed and much research in the field has been dedicated to such ends. Unfortunately, many of the existing approaches in user experience design have shortcomings, including the lack of evaluative techniques, and the lack of a holistic theoretical framework from which principles can be formalized into design actions.

This research study's aims are directed at these shortcomings through the exploration of constructivist design goals, expressed as intentions, and their outcomes experienced by individuals. First, design goals were shown to play an important role in the decisions and evaluation of a product, which is guided by a designer's epistemological stance (chapter 2). Constructivism was proposed as a direction for further research as its principles were found to be at work, both explicitly and implicitly, within current user experience approaches to the design of interactive technologies (chapter 2). With constructivist theory described, museums were demonstrated as being an appropriate environment to understand the implication of design intentions on outcomes, as they are chiefly concerned with designing experiences that are often constructivist in nature, while offering existing evaluation techniques based on constructivist principles (chapter 3). In order to study the relationship between constructivist intentions and outcomes, a multiple-case study approach was taken in which two museums that explicitly used constructivist principles were selected, and a case-study protocol was developed (chapter 4). In both cases, designers and family groups were studied, and the results from the two cases were later compared using a cross-case synthesis approach (chapters 5 and 6). The findings from the study demonstrated that there was a relationship between the intentions of the designers and outcomes experienced, providing evidence of how specific intentions can be combined to create situations that address a variety of experiences to encourage playful engagement, social interaction, and learning (chapter 6). A discussion of the findings demonstrated that this research touches

upon issues related to design practice, such as the formalization of constructivist design principles and their associated impact on the user, while also describing the implications on the area of design research through addressing theoretical issues, and in positioning constructivism as an emerging epistemological approach for design research (chapter 7).

In this chapter, the study's research questions are revisited and their outcomes summarized in section 8.1, which is followed by an outline of future work in section 8.2.

8.1: Revisiting the Research Questions

The direction of this research focused on the application of constructivist goals in the design of interactive experiences, and understanding how the expression of these goals, their intentions, manifested themselves from the perspective of visitors in a museum. To understand this phenomenon, the study presented two research questions to define the scope and guide the research approach. A summary the results for each of these research questions are presented below, along with their related contributions.

Research Question 1:

How are constructivist intentions expressed by designers?

This question was addressed through the presentation of patterns or themes that include sub categories of design intentions (chapters 5 and 6). Together, seven themes were uncovered including: *design for personal experience, design for play, design for social interaction, storytelling, emotions,*

learning, and *design for different audiences.* These themes describe a variety of ways that designers intended to address the visitor's experience, and showed that intentions related to the themes *design for personal experience, design for play,* and *design for social interaction* were most frequently used across both cases. Designers from both museums used similar strategies to engage the visitors, considering the visitor's previous experiences, their level of proximal development, and designing interactives with the affordance for imagination, while also attempting to position family members as resources for interaction and social collaboration and cooperation.

Other themes, such as *storytelling, emotions* and *design for different audiences*, appeared less frequently, but were used in similar ways across the cases to provide structure to the user – addressing issues relating to curiosity, while addressing the needs of different ages and types of visitors. Finally, the themes that were uncovered through this study were often expressed in ways that demonstrate their dependence upon each other; for example, the desire to create situations for social interaction often required decisions to be made surrounding their age and level of understanding – elements that fell within the *design for different audiences* theme. This interdependence of themes speaks to the holistic nature of constructivism itself, which sees experience not as a set of individual elements, but a variety of aspects that are intertwined and combined in the mind of the individual.

By describing how designers express constructivist intentions, this study contributes to existing research that deals with the application of constructivist

principles, which continues to be an area that is understudied. In describing how constructivism may be used in the context of interaction design, practicing designers may gain a better understanding of how to apply constructivist principles, which are often ambiguous and lack clarity in their formalization within the discipline. Though the findings arrived through an exploratory approach, the results provide designers with foot holes to understand how to apply constructivism within an interaction design context.

Research Question 2:

Is there a relationship between constructivist intentions and outcomes?

Through the comparison of intentions and outcomes, this study demonstrated that the intentions of designers related to their outcomes, while also providing an emerging framework that highlights the potential effect of constructivist design moves on the visitor experience (chapter 6). A variety of similarities were found, such as the designers' intentions of using familiar game mechanisms and metaphors to shape the form of the interactives, which helped the visitors readily engage with exhibits, and afforded the opportunity for participants to use their previous experiences to discuss the subject matter of the interactives with their peers. Another example of the relation of intention to outcome was the use of storytelling to help the visitor mentally structure the experience, and it was shown that when the narrative's goal was consistent with the learning goal of the interactive, that participants were able to relate the concept of the interactive to their own lives – rather than merely recalling the narrative surrounding the mechanism of interaction. Numerous examples of this

sort were described in chapter 6 and point to the importance of addressing issues of social interaction, play, and the user's personal experiences, among the other patterns, to address the variety of behaviours (found within the visitor themes) that lead to the making of meaningful experiences. Additionally, the findings point to an interconnectedness of design intentions and outcomes, in which a design decision may affect user behaviours that fall within a variety of visitor themes. In this way, a decision that is made not only affects one measure of success of an interactive, but several, and highlights the importance of considering a user's experience in a holistic way.

In providing evidence of a relation between constructivist goals and outcomes, this study contributes to interaction design practice by describing an emerging constructivist framework that encompasses the formalization of theoretical principles into design actions, and traces these actions to possible outcomes through the use of an evaluation strategy based on the same theoretical concepts. The emerging framework, discussed within this study, is not only valuable to those desiring to employ constructivism within the context of interaction design, but also addresses shortcomings within the area of user experience design, described in chapter 2.

A secondary contribution pertains to design research, in that this study provides methodological insights into the study of designers, the processes they use, and their relation to their outcomes. Further, this study gives rise to an alternative, constructivist design epistemology, where experience and its

construction are central to interaction rather than an independent and measurable phenomenon associated with issues of instrumental usability.

8.2: Directions for Further Research

This research study's approach to the investigation of constructivist intentions and outcomes took an exploratory and descriptive approach, which was aimed at better understanding the aforementioned phenomenon, especially with regards to the area of experience design. Given this approach, a number of areas for further research have been exposed.

First, the findings present the starting point for a constructivist interaction design framework by describing a number of themes based on several designers' intentions. Further studies to the one described in this study should be conducted in museums, along with other contexts where experience is a central concern in order to understand whether the themes presented in this study persist across other areas where interaction design takes place. Doing so will help to better understand whether these findings are relevant solely to museums, or is a general phenomenon within constructivist interaction design. Additionally, the study of other sites should include contexts where learning plays a lesser role within the overall experience, which will provide valuable insight in the applicability of the design intention themes to non-learning environments.

In accordance with the former point, a second research effort should consider the adaptation of the constructivist evaluation tool used in this study for other, non-learning contexts. Currently, the evaluation tool is directed towards

museum environments and consequently involves metrics that revolve around learning. As discussed in chapter 7, the adaptation of the evaluation tool would not require significant changes, but would require testing in the field to both validate and understand its usefulness to more general design contexts.

A final research direction should consider how the findings from this study might integrate with existing experience design approaches, especially those that approach experience from a phenomenological perspective. Though a number of phenomenological strategies exist that bear similarities with this study's findings, a more comprehensive examination of the relation between constructivism and phenomenology – within the context of interaction design – is needed. As these two theories hold similar epistemological underpinnings, the potential benefit of such work would include the development of an understanding of interactive experiences that spans a variety of contexts, the development of a common language to discuss phenomenon, and the development of evaluation techniques based on their common understanding of experience.

In conclusion, a constructivist approach to experience design entails a shift away from thinking solely about interaction from the perspective of the artifact, to considering experience as the focal point. This shift in perspective suggests the importance of considering the processes by which people make meaning from experiences, while highlighting the concern to design appropriate resources and scaffolds, to facilitate them in doing so. This research hopes to contribute to this endeavour by exposing a series of patterns, and encouraging their use and elaboration in the development of future interactive systems.

APPENDICES

Appendix A: Designer Interview Protocol

Introduction

Thank you for participating in this research study. This study focuses on the relationship between design intentions and their outcomes, as experienced by family groups in museums. The first part of this study involves the interviewing of designers in order to understand how the goals and intentions are expressed. I have a few questions today that I would like to ask, and feel free to elaborate on these questions, as the interview will take a more semi-structured approach

Questions:

1. What were the main ideas /goal you wanted to communicate in your exhibit?

2. What was your role in the project?

3. What learning goals did you have in designing the exhibit?

4. Do you think that using the constructivist perspective was helpful?

5. How do you think the project used constructivism versus a classroom setting?

6. Who else worked on this project? How did you communicate these goals?

7. Were there any principals that helped guide you in your design and concept planning?

8. What areas did you research?

9. What considerations were made so that the exhibit appealed to your audience?

10. Could you talk about the unsuccessful parts of the project

11. Do you have any comments or questions?

Topics to cover:
• Your role in the development of BodyWorks 2.

• The approach in the design of the exhibit.

• Better understanding the requirements / and goals of the project

• Understanding how the goals were realized / how they manifested in the actual exhibit.

• The role of specific aspects such as social context and engagement and how they are manifested in the exhibit.

• Successful and unsuccessful aspects of the exhibit.

Appendix B: Family Visit Protocol Sample (Science World Case)

Family Museum Visit Protocol

Logistics: The front desk knows we're bringing people through and should not ask for payment. I will have movie passes for them, to hand out at the end.

Introductions & IceBreaking: (10 minutes)
Introductions: Introduce yourself and have each family member introduce themselves. Try and get everyone, especially kids, to talk. Get consent forms signed.
Previous Experience: Probe on their previous museum experiences, in particular trying to find out:
1) Their museum routine: How frequently do they visit museums, which kinds do they visit, and if have they ever been at the Surrey Museum?
2) Museum meaning: Why do they like museums, what do they get out of them?
3) Connection to Surrey: Do they have a connection to Surrey? Are they interested in learning more about it? What do they already know?
Keep this conversational and informal as much as possible
Specific Story: Try and solicit the story of one particular museum experience-their most recent, most fun, etc. Get them to think about what they did there, how and if they felt they learned.

Visiting the Museum: (20-40 minutes)
Advice for the Family: Invite the family to visit the museum, describing the aim of the study as finding out how families visit the museum so that we can better design technology to support museum family visits and better inform designers on creating more engaging experiences

I will ask the participants to wear a lapel microphone, and wireless transmitter, and inform them that the audio recording will be used solely for my study, and will not be shared with anyone else. Additionally, they will be informed that they can decline to use the audio devices, and choose to quit the study at any time.

The audio devices will be tested to ensure that they are working, and I will begin the recording on a device that I will carry on me.

The participants will be observed using two facilitators.

Things to visually observe:
• Actively Involved in learning
- standing and looking/ reading
- exhibiting curiosity & interest by engaging with an exhibit
- absorbed, close, concentrated observation
- persevering with a task

• Purposeful Manipulation
  - handling exhibits with care and interest
  - purposefully 'playing' with exhibit elements / using hands on exhibits as intended
• Sharing Learning (including helping others)
  - talking and pointing
  - pulling others to show them something
  - willingness to be pulled to see others' interests
  - group members talking and listening
  - asking each other questions
  - talking to adults / experts

• Making Links and Transferring Ideas and Skills
  - Comparing Exhibits
  - Referring to prepared questions
  - Comparing / Referring to previous experiences

• Non-Learning
  - walking quickly through the exhibit
  - watching other visitors

Things to observe through listening:

• Initiate Own Learning
  - know what they want to look for / making choices
  - talking to themselves
  - deciding where and when to move

• Actively Involved in Learning
  - See above

• Sharing Learning (Including Helping Others)
  - See above

• Non-Learning
  - talking about things non-related to museum exhibit

• Emotive Responses
  - Reactions that relate to the way the participant feels about exhibit

• Making Links and Transferring Ideas and Skills

Follow-up: (10 minutes)

After leaving the museum gallery, the participants will be asked to provide feedback on their experience. This will occur in a private room in the museum. I will ask the participants to continue to keep their microphones on, in order to have an audio recording of the follow-up session.

• A short, semi-structured interview will ensue with the family, to find out:

1) What they thought the main messages that the exhibition is trying to communicate?

2) Were there some things that they found particularly interesting in the exhibition that they might tell others about?

Follow-up: (2-4 Weeks later) (10 minutes)
- A self-administered interview package is provided to the family that includes interview questions, a recording device with instructions, and a self-addressed envelope. The family is instructed to ask each other questions, with one adult acting as the interviewer. The questions used are listed below:

12. What interested you about the museum before our visit?

13. Was the museum visit like you expected or different?

14. Tell me what you remember about your day at the museum?

15. What other museum visits can you remember, was this different in any way?

16. What did you like best about the day?

17. What part did you like the least? Did you have any disappointments or frustrations on or about the day?

18. Tell me about what you did in the Body Worlds area? Was there anything in particular that you remember the most?

19. Are there any things that you saw at the museum that you would like to find out more about?

20. What would you tell others like your friends about your day at the museum?

21. Did you feel that you learned about Science? If so, what did this visit make you think the most about?

22. What do you think the main ideas that the exhibition is trying to communicate?

Appendix C: Code Tabulation and Frequency

Designer Interview Data Tabulation by Participant ID:

Designer ID: 7

Designer Interview Themes	Instances	Total	Avg.
Personal Experience	27	120	23%
Design for Play	25	120	21%
Design for Learning	20	120	17%
Social Interaction	11	120	9%
Storytelling	11	120	9%
Different Audiences	5	120	4%
Design for Emotions	7	120	6%
Challenges	14	120	12%

Designer ID: 8

Designer Interview Themes	Instances	Total	Avg.
Personal Experience	123	383	32%
Design for Play	91	383	24%
Design for Learning	68	383	18%
Social Interaction	34	383	9%
Storytelling	14	383	4%
Different Audiences	23	383	6%
Design for Emotions	1	383	0.30%
Challenges	29	383	8%

Designer ID: 9

Designer Interview Themes	Instances	Total	Avg.
Personal Experience	47	312	15%
Design for Play	112	312	36%
Design for Learning	10	312	3%
Social Interaction	36	312	12%
Storytelling	2	312	1%
Different Audiences	25	312	8%
Design for Emotions	15	312	5%
Challenges	65	312	21%

Designer ID: 10

Designer Interview Themes	Instances	Total	Avg.
Personal Experience	94	262	36%
Design for Play	60	262	24%
Design for Learning	9	262	3%
Social Interaction	18	262	7%
Storytelling	19	262	7%
Different Audiences	29	262	11%
Design for Emotions	6	262	2%
Challenges	27	262	10%

Family Visitor Code Tabulation By Case:

Kurio Family Visitor Groups

Family ID	13		15		21		Avg.
	Inst.	%	Inst.	%	Inst	%	
Audio Data Themes							
Sharing Learning With Peers	96	24%	89	28%	146	34%	27%
Actively Involved in Learning	73	18%	50	19%	73	17%	18%
Showing Confidence in Learning	41	10%	22	8%	42	10%	9%
Showing Responsibility for Learning	51	13%	40	13%	23	5%	10%
Responding to new Information	9	2%	6	2%	8	2%	2%
Making Links and Transferring Ideas	25	6%	6	2%	7	2%	3%
Non-Learning	100	25%	67	25%	92	21%	24%
Visual Data Themes							
Sharing Learning With Peers	128	24%	67	24%	162	28%	25%
Actively Involved in Learning	182	29%	87	31%	194	31%	30%
Showing Confidence in Learning	17	8%	12	4%	30	5%	7%
Purposefully Manipulating and Playing	47	9%	22	8%	47	8%	8%
Showing Responsibility for Learning	38	7%	19	7%	36	6%	7%
Non-Learning	122	23%	74	26%	132	22%	24%
Self-Administered Interview Themes							
Sharing Learning With Peers	2	2%	5	4%	–	–	3%
Actively Involved in Learning	20	18%	35	29%	–	–	25%
Showing Confidence in Learning	0	0%	0	0%	–	–	0%
Purposefully Manipulating and Playing	23	18%	18	15%	–	–	17%
Showing Responsibility for Learning	2	2%	4	3%	–	–	3%
Responding to new Information	6	5%	10	8%	–	–	7%
Making Links and Transferring Ideas	1	1%	6	4%	–	–	3%
Non-Learning	0	0%	0	0%	–	–	0%

BodyWorks 2 Family Visitor Groups

Family ID	2		4		5		Avg.
	Inst.	%	Inst.	%	Inst	%	
Audio Data Themes							
Sharing Learning With Peers	85	37%	150	42%	117	40%	40%
Actively Involved in Learning	34	33%	48	30%	45	26%	30%
Showing Confidence in Learning	26	11%	47	13%	23	8%	11%
Showing Responsibility for Learning	22	10%	25	7%	46	16%	11%
Responding to new Information	10	4%	9	2%	7	2%	3%
Making Links and Transferring Ideas	8	3%	17	5%	11	4%	4%
Non-Learning	14	6%	13	4%	14	5%	5%
Visual Data Themes							
Sharing Learning With Peers	15	16%	28	21%	45	27%	21%
Actively Involved in Learning	65	28%	100	28%	78	26%	27%
Showing Confidence in Learning	13	15%	11	8%	19	11%	11%
Purposefully Manipulating and Playing	19	21%	30	23%	26	15%	20%
Showing Responsibility for Learning	9	10%	20	15%	22	13%	13%
Non-Learning	4	4%	2	2%	14	8%	5%
Self-Administered Interview Themes							
Sharing Learning With Peers	1	3%	0	0%	0	0%	1%
Actively Involved in Learning	12	33%	16	23%	15	25%	27%
Showing Confidence in Learning	0	0%	0	0%	0	0%	0%
Purposefully Manipulating and Playing	14	39%	16	23%	11	18%	27%
Showing Responsibility for Learning	1	3%	1	1%	0	0%	1%
Responding to new Information	2	6%	5	7%	6	10%	8%
Making Links and Transferring Ideas	3	8%	9	13%	5	8%	10%
Non-Learning	0	0%	0	0%	0	0%	0%

Appendix D: Sample Designer Interview Transcripts

Kurio Designer Interview
Participant: 07
Date: March 17

Facilitator: Kevin Muise (R)
Participant (P)

R: What was your role in the Kurio project?
P: In the Kurio project, I was one of four graduate students working as, pretty much full time on the project while it was running. My role... um... most specifically was designer of the reasoning engine that underlay the interaction model, but as the project developed… at the beginning I wasn't paying much attention to some of the other stuff, like content development, design of the tangibles, that kind of stuff, but as it developed, I found myself in more of a lead role where I was not designing those things, but coordinating those designs and often people would be coming to me with questions about how everything was fitting together. So in the end, I feel like I sort of designed how they all worked together as a system and I often felt like I had a pretty good sense of what was going on in a global sense, sometimes more so than the other people. So, particularly in terms of the table design, I worked very closely with the person who was designing that. While he did the coding I was always there to make sure that what the result was, was actually something that was going to work with the rest of the system.
R: Ok, so what were the kind of things guiding you in how you designed and thought about the table interaction, or thought about the reasoning engine?
P: One of the things that informed me to a great deal was the study that we had done at the museum the previous summer. We had seen people interacting, outside of any technological mediation, we had seen a lot of interaction between the adults that was lightly educational and that the adults were trying to prompt the kids for some kind of response or to try to get them engaged or the adults were telling the kids stories from their past or other things that they knew. And so one of the things that I kept thinking about when we were talking about the way in which all these devices and system and stuff were going to work together was whether or not that would be interfering with that process. Whether or not it would be contributing or problematizing it. And then there were always these technological concerns, like how can we make this robust. Or how can we make this not fail if one component breaks down or if one thing has to be pulled off line. There are lot of technical problems with the system. So there was a lot of bouncing back and forth in trying to keep in mind what the end goal was, and keeping the users interacting with each other, as well as the technology… and also making sure that the technology was robust enough to handle that.
R: Ok, Could you clarify as to what you saw the main goal as being?
P: The main goal, I saw, was to encourage social interaction between the participants that also gave them additional information that they would not have if they were visiting on their own.
R: Learning also played a role in this project, and so what did you see as learning goals?
P: For their learning goals, we were designing… and this is where the adaptive model and the reasoning engine came into play more… was to sort of, to find peoples' level of challenge, where we weren't giving people information or tasks that were too easy and we weren't giving people tasks that were too hard. It was really right about that appropriate level that was interesting and intrigued them, but they didn't know the answer right away, but that they could find the answer, with a minimum amount of effort by going out into the museum or interacting with their fellow compatriots. So for me, in sort of designing both the algorithms that underlay the task assignments and in designing the system as a whole and how it interacted, I was always trying to find that peak level of challenge, where people would be engaged, but not frustrated. And so technical reliability played a large part in that as well – to keep the frustration level down, meant

that you could make the questions a little harder if they were not wrangling with the technology as much.

R: So could you talk a little bit about, making it not so hard or so difficult?

P: Yup, so the primary way that we did this was that each of the tasks were categorized according to learning levels, whether they were easier, in terms of remembering or understanding, or whether they required analysis or application of knowledge… and so each of the tasks in the system were categorized according to those ways and when we went to assign the task, we would look at what we knew about that person already. If they had done a task already, on that level, and done well at it then we would try to give them a harder task. But if they had done a harder task and failed at it, then we would move them back down. And so that was the basic mechanism, the algorithm, there were a series of questions, also, that were asked at the end of each task, – whether they found it hard or not, whether or not anyone helped them get it – and that was also factored into whether we considered the task successfully completed or not. And that affected, in the future, how they got assigned tasks.

00:05:43

R: A little bit on the learning levels… where did that come from?

P: Yeah, they were based on Bloom's taxonomy, so the person who designed the content for the system sort of rated everything in terms of Bloom's taxonomy when they put them into the system

R: In terms of these goals, how did you communicate these goals across the various members in the project's team?

P: That was always something that was… a work in progress… there were some members that came later in the process, and so we had to bring them up to speed. The person, who was working on the table, almost had no time to come to full meetings and really engage in the project as a whole. People didn't always have time come to project meetings. I found the project meetings very helpful, but it got later in the project, they felt that they became more of a distraction from getting the actual work done. We had to go and talk about for an hour, what you had just done, instead of doing it… but in general, the project meetings were a good way to come together and remind ourselves what we were all working on, so that we kept a picture in our minds of how it was all coming together. Then in the final stages, when we were really pushing to get it into the museum, we had a lot of one-on-one meeting with people that were working on different things. I would sit down with Greg and work out the tangible-server communications, I would sit down with Bardia to go over the PDA-server communication, and then with Jay and the table. Then we would start bringing in more people, and more components connected together until we got the full system working.

R: Ok, in terms of these goals… and I would like to focus on how the understanding of these goals were spread from different team members. From my own knowledge of the project, after an initial literature review, some processes of participant observation – there was this notion of constructivist learning, coming into play and becoming an underpinning.

P: Right

R: Could you speak a little bit about your feelings about that?

P: The constructivist learning, I had really mixed feelings about, as the project went back and forth. I think in the end, it was really hard to design for. We had so many components to the system, and constructivist learning was really about flexibility and about people bringing their own understanding to it. I felt there was a danger with all the stuff that we were giving them. The game structure, the narrative with time travel, the devices, the videos on the table – that we were overwhelming them with our own content, our own interpretations. But, in the end, the museum itself is full of content as well, it is full of things to interact with, and to explore and to experience – people still bring their own interpretations to it.

So I think that the best thing that we did about the design, in terms of constructivism, is that we forced people to talk to each other. They had to communicate between the kids when they used the devices to pick them up and the parents saw the results of that, and there had to be that back and forth. Where a kid had forgotten what their task was, and the parent reminded them, and they negotiated whether it was the correct answer. So I think that was a success on a certain level.

I think the overall playfulness of the devices and everything contributed to a feeling of bringing, you know, your own ideas and stuff… it didn't look educational on the surface of it, and so I think it fostered a more playful learning style

As far as when we were actually doing the design, and thinking about constructivist learning, in a lot of ways I tended to – when I was working on the reasoning engine I was thinking about learning a lot because I was trying to develop an algorithm that fostered learning. When I was working on some of the other stuff, with the PDA, the table and the communication system, I mean, the learning factor was sort of irrelevant. So I'm not sure if the learning goals were always foremost in my mind, I was just trying to get everything working.

R: So a lot of it, in terms of the technical side was just trying to get it working, instead of thinking about these underlying principles.

P: Yeah

R: Do you think that using the constructivist perspective was successful?

P: I think it was, I mean, but I think in a lot of ways what constructivist learning says, I mean, it argues that learning is constructivist inherently. That even if you try to give them a very structured path pedagogy that people are only going to learn are capable of learning. So I am glad that we didn't take a very dogmatic approach, I don't think that that would have worked very well for what we were trying to do. It wouldn't have been as playful or as interesting, probably. So I think that constructivist learning was an appropriate path to take it just felt that sometimes that it wasn't giving us enough structure to make actual design decisions that would have been easier if there was a more rigid framework.

R: I see, so there wasn't a sense of a structure

P: yeah

R: So here are some principles and… (interrupted)

P: Here's how we know that learning is going to happen. You know. That would have made the design process easier, but I don't know if it would have made it better.

R: What kind of considerations did you make to ensure that the system appealed to your audience?

P: Well, a lot of it wasn't in my direct control. I mean, the reasoning engine, and all the algorithms were pretty abstracted from anything that people actually encounter, and a lot of it was hard to see the effect of until it was actually out in the museum. I think that the design of the tangibles had a big impact, although I had no part of that. But the shapes and the colours and the design of the tactile experience of the devices had a big impact on people's experience of the project and their enjoyment of it.

The writing of the content, I tried to do some of work with that to make sure that the content was at the right level and the appropriate stage, but it was hard because it was such a massive database of things to be working with.

What else… the table. I did work closely with the person who designed the table, but again we were… that was a point that we were really running out of time. So a lot of things that we would have liked to do, to make it prettier, more appealing, or even more educational had to fall by the wayside to make it work on the basic level. But in the end, I think it all came together reasonably well.

R: Could you talk a little bit about the unsuccessful parts of the Kurio project?

Technical reliability really was the kicker in the first phase of the research, the system just didn't perform well enough on a technical level to allow people to relax into it. They never got comfortable with the system and as soon as one thing broke, they started questioning everything else about it. And started looking for other ways that it might be broken. And that I think completely obscured the learning, the education and everything else that was going on. SO that was really the biggest thing. By the second phase it was much more robust and we saw a clearer picture of what the experience actually could be of people interacting. We had people in that second phase, more often, say "I want to keep going", "I want to keep playing", "I have the hang of it", "I'm enjoying it". They would get into what we call the flow state, you know, sort of picking up the devices, doing the tasks, and understanding how the whole thing worked.

I think if anything was unsuccessful… we probably should have spend more time on the tutorial. The tutorial was sort of added at the last moment and without really thinking "oh, we are

going to have to explain this fairly complicated system to them to people". So I think that there was a certain level of learning of the system itself before you could even access the learning about the content. And, as it worked out, it ended up that the first exhibit, the aboriginal exhibit, really was the tutorial. And so, I don't know how much they really learned about Aboriginals, because they were so busy learning how to use the devices, what the task / answers structure was, how does the interface… and all this other stuff

R: So you see those things as getting in the way of actual learning

P: Yeah. It wasn't until they mastered the interface, and the game play, and all that kind of stuff, that they could really engage with the museum content and the things we were asking them to do – to learn about

R: Okay… so I would like to go back to your role as developing the learning levels and how those are adapted… in terms of the personalization, within constructivism, it is an important aspect. I am wondering how you might have seen that realized.

P: We had individual user models for each of the people who were in the system. So we knew going in, things like their name, their age, and then as they interacted with the system, we developed an individual history for them; We knew things like, you know, whether they got the question right, at what level that question was at, whether they felt it was easy or hard. And all these things became factors in the model in terms of what they got next. So on that level, I think that was really what the individualization of it came. It would have been fun to more individualization than we did, but we didn't have time, really, to test the model out and especially afraid of making it too complex. But we could have factored things in like how long, on average, it took to complete the task and get some idea of what would be the ideal length of task … or something like that. But we would have needed to know a lot more information on each of the individual tasks, and how long they would take and so on. But… I think of what we did worked fairly well, although it would have been fun to add more factors in.

R: In terms of engagement, how do you think that that was applied in the project?

P: One of the things we did was in the task assignment algorithm and reasoning engine, we tried to move the devices around. So if the person that had the text reader… we wouldn't give him the text reader again, if we could help it, for the next task. And I think that the idea there, at least, on the surface was that it would be more fun to be continuously switching the devices around, and to trying everything. So we didn't want one person always feeling like they were stuck with the same device, or if their sister was using the cool one, or whatever. So we wanted to rotate them around and give everyone a shot at everything.

We also… this is kind of an indirect way of measuring engagement, but we did have, for the group as a whole, we did have a sensitivity to time. So if they were taking a really long time to do things, we tried to be sensitive to that and not create frustration by continually assign them more tasks if it was taking them forever to get…

R: Right

P: So we tried to find a balance between sending them out and bringing them back in at approximately the time that we felt they were done. So we didn't keep them out there feeling frustrated, but if they were going through them very rapidly then we kept giving them more tasks, because they seemed to be engaged with it.

R: So in terms of this kind of "coming-and-going" of people, there is somewhat of a structure that exists, however in constructivism, there tends to be an unstructuredness, so how do you think these things come together?

P: That's a good question, the activity structure was fairly rigid, in terms of like the... they start at the table and they go and do some tasks, and they brought them back for these different rounds, but we had a lot of flexibility in the system in terms of how many tasks they got while they were out, how much time they could take, and they could always switch things around, and we allowed them to exchange the monitor if one of the kids really wanted to use the PDA instead. So I think that there was sufficient structure that was required for the narrative and for the game that they were playing, but that they really had flexibility within that structure to take the time they needed to take and do the things they needed to do. And when they would come back, at a certain point, they would get this little lesson, it wasn't a lesson, it was more like a reward – some additional information that wasn't available in the museum, which in theory they could, you know, take however they wanted to… more information they could incorporate into their personal learning

R: How do you think Kurio used constructivism versus a classroom setting?
P: I think Kurio had a lot of constructivist elements to it. We did mark things correct or incorrect, so that they could see when they came back, if they got it wrong in order to allow them to learn, but it didn't really have an effect. I mean, it's not like getting something wrong prevented them from learning things later – it affected the choice of what they got to do, it's not like we failed them (laughs).

We kept the game open-ended, it would keep going even if you were having trouble, you know, you could still enjoy it, even if you were not getting things right at all. And hopefully they were learning something, even if they were not getting the answers right. And so I think compared to a classroom, I hope at least that it was an environment in which it didn't feel like there were heavy consequences to getting things wrong. You could play around with it, you could try to learn some things, you could guess, take some risks in answering questions, you didn't have to worry about your grade hanging on it

R: You spoke a little bit about this underlying narrative, and make you could talk a little bit about that, and it's role.
P: The narrative was that the families who came to the museum were time travellers who had been stranded in Surrey in the past, and they could only fix their machine by going through the museum and learning about the history and that would help their computer fill in the missing information. We had had at one point a sort of a puzzle metaphor going on as well, that they were collecting puzzle pieces and that filled in the gaps somehow – we still had that metaphor, at least on the visual level, but I'm glad that we didn't have that too strongly, because it didn't feel like you had to collect specific puzzle pieces to fill specific gaps or anything like that. It was a very loose structure. You had to get some information, you didn't know exactly how many. It wasn't as if you had to collect 20 coins or whatever, and so I think that played into the constructivist aspect as well. You weren't searching for specific information, you were just searching for information, and really it could be any information you were interested in.

I think the narrative was maybe a little over complicated, given all the other stuff that was also going on with the devices and everything, but I think it was fun. I think it was engaging, and people seemed to get it after the initial "Oh, we're time travellers, oh". I think they did like it in the end

R: Why was the underlying narrative important?
P: I think it answered the question "why are we doing this?" I think that, especially kids, like to ask "why do I have to do this?", so I think it answered that in a basic way. In a way that was "you have to do this because the researchers are telling you". So I think some kind of narrative was required, and the time traveller thing actually worked fairly well. It gave it a sense of a goal, it wasn't just "go out and do 'X' number of tasks". It made it a little more playful and I imagine it was something that they talked about when they got home – "oh we got to be time travellers", time machines, that kind of stuff… more so then just "oh we went around the museum, and picked stuff up".

I think it gives them a way to think about it.

APPENDIX E: EXAMPLE FAMILY VISITOR IN-MUSEUM AUDIO TRANSCRIPT

Kurio Case Family ID: 13

Transcriber: Kevin Muise
Adult: Carrie / **Children:** Amy, Danny

Time	Name	Transcript
0:00:00	Transcriber	*The tape begins with the researcher asking the family to explore the museum and introducing Kurio and the research team. On of the researchers provides a tutorial which is not transcribed*
	Danny	Why don't we have the two… [commenting on the devices not available, but shown in the video]
	Researcher	**Those are two that we are still working on. We were having some slight problems with them during the week, so we decided not to use them.**
	Amy	Is this a map?
	Researcher	Yep, this is your time map, so right now it is broken, and as you fix parts, it will go green. Are goal now is to fix the time map so you can get back to the future. Now here there are different activities. The first activity that you guys are going to do is the aboriginal activity.
0:09:08	Transcriber	[the video plays a little more regarding the first mission] [the researcher gives the various tools to the participant and provides more information about it]
	Researcher	**So the computer is going to assign you task...**
	Carrie	Read it out honey.
	Amy	[begins to read task out loud] What is a petro…
	Carrie	Glyph [following up to help Amy pronounce the term]… well I don't know….
		Find out what this is by using the reader to complete your task...
	Amy	That's the thing that I use.
	Researcher	**Danny, what does yours say?**
	Danny	[reads the task description uninterrupted]
	Researcher	**Well, the pointer isn't working right now.**
0:10:26	Danny	Dang.
	Researcher	**So, Carrie, you're going to use the monitor, so it is loading information right now, and when it's done you should see, hmmm it's taking a long time to load right now.**
	Danny	It's kind of like a scavenger hunt.

		The researchers talk to each other regarding the issues with the system - they decide to restart the system
	Danny	Say if we forget our task, is it on the monitor?
	Researcher	**Yes**
0:12:29	Danny	Good, because I just forgot my task
	Transcriber	The researcher explains more details regarding the functioning of the system.
0:13:36	Researcher	**Do you remember your task?**
	Amy	Hmm... Sort of.
	Carrie	Do you?
	Amy	Not really
	Carrie	[laughs]
	Carrie	You have that funny word that you have to find out... And you have to find something with an animal part.
	Transcriber	The researcher explains some further details regarding the tags.
	Danny	That's what the world is.
	Amy	I just pressed the button
	Researcher	There you go... So if you press the blue… press the puzzle… and it will show you what you selected.
	Carrie	Ok, so rock carvings, also known as petroglyphs are images [she continues to read the item description until it end]
	Amy	That's what I want
	Researcher	**So if that's what you want, then press…**
	Carrie	So that's what it was... A rock carving?
0:14:28	Amy	Yep.
	Carrie	[reading didactic tag] This rock carving was found it the beach area ten thousand years ago…. Oh, wow…. Okay, so we're done.
	Researcher	**Okay, so select review... No, done… just select anywhere on the screen… no just tap... Ok, review... So did anyone help Amy, if no, then just press continue. Amy, did you find this task easy, just right or hard?**
	Amy	Easy.
	Researcher	**Okay, so your mom will tap easy... And you have a new task... So view task.**
	Carrie	SO this is a new one... Okay, [reading] so select an item that could be used to transport people
	Danny	[is reading along with Carrie] ...Over water, use the pointer to complete this task.
	Researcher	**We'll go back to the table, or Greg has it... So you can trade the reading tool for the pointer.**
	Amy	Oh, I need the pointer?
	Researcher	**So, let's find yours, what's your task?**
	Danny	Umm...

206

	Coren	Do you remember what your task was Amy?
	Amy	Yeah… it's the traveling on water.
	Transcriber	The researcher continues to help Carrie with understanding the interface on the PDA
	Danny	[reads his task from the PDA screen]
	Researcher	**Do you want a hint?**
	Danny	Oh, No.
	Amy	And, by the way, I got one.
	Carrie	You have to go and find a display that was made out of parts of an animal.
	Amy	Which isn't a canoe.
	Carrie	Is this all the aboriginal
	Researcher	**This is all aboriginal, there's also in here.**
	Carrie	Okay, so we are on Amy... So...
0:16:37	Amy	Tap the blue.
	Carrie	You already got that one?
	Amy	Yeah, I already got it.
	Carrie	Oh, a dug out canoe. [she then continues to read the item description for the canoe]… we had seen that at the anthropology…
	Amy	And… go back to, then done.
	Carrie	Yeah, but I'm on Danny
	Amy	No, you're not, you're on Amy.
	Carrie	Review... Did anybody help you?
	Amy	No
	Carrie	Review... Did Amy find the task...
	Amy	Easy
	Carrie	Wait for your new task… [reading]… you have received a new task…
	Amy	[reading] Hunting.
	Carrie	K... [reads the task description out loud] … okay so you want to get the pointer and then it says compare the tools that can be used to hunt, which ones do you think would be most successful…the ones that would be best for hunting. Use the pointer to select ... did you get that?
	Amy	The best for hunting.
0:18:05	Carrie	The tool... We are still on aboriginal... so let's go Danny.
	Transcriber	The researcher helps Carrie to quit Danny's task.
	Danny	[Reading] There is no new tasks for you at this time, please help the family members…. I don't do anything!
	Researcher	**You'll do something next round**
	Transcriber	The researcher explains the problem to them.
	Carrie	So we'll help Amy then.
	Amy	So, Task info... Oh, sorry.
	Carrie	Okay, so Danny... Compare the tools that could be used…

	Amy	No, that's for me… I know, but he's helping you because he doesn't have a machine... Next time he will do it. [she then goes on to read the task aloud]
	Danny	There is a bow and arrow over there, but I don't see a white thing...
	Carrie	Okay...
	Danny	There's more over here…
	Carrie	So you have to find… the pointer needs one of those things on it.
	Researcher	**Those are arrows... So that should have worked.**
	Carrie	So, you got a blue puzzle… well that's good… you got arrows [she then reads the item description for arrows aloud]… okay, so that's done…
	Carrie	Danny did you help?
	Danny	No.
	Amy	Yeah, Danny helped
	Carrie	Did Amy find the task easy, just right or hard?
	Amy	I wish there was an in-between for easy and just right.
	Carrie	Let's do just right, because you actually had to look a little harder this time... [reading] you have received a new task…. There are no new tasks for you at this time please help your family member.

	Researcher	**[he explains a task to Amy]... That was your first one, right?**
	Amy	No
	Researcher	**Second?**
	Amy	Yeah, that was my second one.

	Transcriber	Researcher explains the significance of the red puzzle piece to Carrie.

	Amy	So, I got them all right.
	Researcher	**So, if you look here, let me just clear this out of the way. We have a puzzle, but the puzzle is not completely done. So we need to complete the puzzle in order to move on.**
	Carrie	Oooohhhh… So, these are the ones that we've done.
	Researcher	**No, these are the ones that you have found…**
	Carrie	So we want to complete the picture not take away the ones we've done.
	Researcher	**That's right**
	Amy	So Danny, we have to do some of your stuff.
	Carrie	Yeah...
	Amy	So here's a working pointer.
	Carrie	Pass that to Danny.
	Amy	But it's not green.
	Carrie	Well, it's loading up, you have to wait.
	Danny	Where's the red tagged, or black tagged?
	Researcher	**It's loading up**

	Danny	[reading the task aloud] Locate the rock carving in the museum in order to activate the listener.
	Amy	So is this still the aboriginal?
0:23:13	Researcher	**Yes.**
	Danny	[Reads the rest of the task description]
	Carrie	I'll take Danny over there, and you [she then starts reading another task out loud]
	Researcher	**I'll help you with... Let's find the rock carving... Do you remember the rock carving at all? [the researcher helps him with the listener tool]**
	Danny	Yeah, it's right there.
	Amy	Would this be in the aboriginal as well?
	Carrie	Yeah, right over here...
	Amy	So… it said... How do you cook food and heat your home…
	Carrie	It said... Find the rock caring in the museum…. Oh, no, that's not it.
	Amy	This is Danny's
	Carrie	That's Danny's
	Danny	[listening to the listener tool]
	Amy	What did that say?
	Carrie	Press this button?
	Researcher	**No, I'm talking to Danny.**
	Danny	[still listening to the audio]
	Amy	I have the long houses... But it says, what do you use to cook your food… So a fire, for heating and cooking… so what do I press... To I get both?
	Researcher	**Which one do you want?**
	Amy	Both.
	Danny	None of them said anything about that.
	Amy	So it said, how would you cook and... warm the longhouses… they were both the same answers
	Carrie	Shells and stuff were found…
	Danny	Is this it?
	Carrie	Yeah, it's the second one.
	Danny	This one?
	Carrie	The one we just listened to… yes.
	Researcher	**Did it vibrate?**
	Danny	Yeah.
	Carrie	[She reads Danny's selected item description out loud]
	Researcher	It should be said that that is the right answer, but the description isn't that good...
	Carrie	Okay... So did anyone help you?
	Danny	The monitor.
	Carrie	Did you find it easy, just right, or hard?
	Danny	Just right.

	Carrie	You have received a new task. [reading]
	Amy	Can you look at mine?
0:26:39	Carrie	Yeah…. So let's do Danny's here, and then we'll do yours.
	Danny	[reading together with Carrie] There are no new tasks for you at this time…. No new tasks [he corrects his mother as she read it wrong]
	Carrie	Okay, so we'll go back to Amy's
	Amy	Now press it.
	Carrie	Oh, you did the long house?
	Amy	Yeah.
	Carrie	[She then reads the description for long houses out loud]
	Amy	No, press trash.
	Carrie	But you did it… [she then reads the description again]... So you've done that one...
	Amy	No, no, no, Press trash.
	Carrie	Why?
	Amy	Because I don't know… just press it.
	Carrie	But I don't... know...
	Amy	Just press it again.

	Carrie	Oh, I see what we do… [reading the task description for Amy … ' if you lived in a longhouse']
	Amy	Yeah, it was the second one...
	Researcher	**Yeah, I think you're right...**
	Amy	Yeah, It was either that one, because it talked about the coast Salish... And the other with the cooking, and I'm not sure which one it is.
	Amy	It's this one.
	Carrie	Really?
	Amy	Press it.
	Carrie	Good, the hearth... [reads the item description]
	Amy	[interrupts her mom reading]... Yeah, that's the one… press done.
	Carrie	So, did anyone help you?
	Amy	No
	Carrie	Did Amy find the task easy or just right, or hard?
	Amy	Easy... Or maybe just right.
	Carrie	I would say just right because she actually had to think about it the second time.

		The researcher then goes through the various artifacts that were collected… there was an incorrect answer, but the researcher explains it as being a glitch the system…the researcher then shows them the completed section on the time map.

Carrie	Oh, that's one of the museum things.
Danny	Is this like the final.
Researcher	**That's what we are trying to do, is reconstruct our time map. Now we have a choice, we can explore the trades or farming.**
Danny	Ummm... Let's do trades.

0:32:07	Transcriber	The trades intro video plays.

Researcher	**Do you want to listen to the other one?**
Carrie	No, we'll just go with that
Researcher	So Amy you have a task, and now you are going to use the monitor.
Amy	Yeah...
Carrie	Don't drop it okay.
Amy	Okay.
Carrie	[reading aloud] Use the reader where many saw mills are located today.
Danny	[reads his task aloud]
Carrie	You gotta find blacksmith tools… and I have to find... What was mine again?
Danny	Find the blacksmith.
Carrie	What was mine again?
Amy	[she reads the task to Carrie]
Carrie	Where many saw mills are located today.
Amy	Danny, your task is to find two tools that could be …
Danny	This isn't going blue
Carrie	Well, okay… you have to pick the right tool.
Amy	[reading to them… 'find two tools'…]
Carrie	What would have the blacksmith made
Danny	Not an anvil.
Carrie	No... But they would make like a horse...
Danny	Horseshoe... Hooks.
Carrie	Hooks, yeah.
Danny	I'm looking for the ones that...
Carrie	Any of those things… see those metal things there.
Danny	It's not blue
Amy	Maybe because it says the pointer... Not the black tabbed… it says use the pointer
Danny	Well, it said in there, and he handed it to me.
Researcher	**Let me take a look at it.**

Note: "0:34:08" appears in the left timestamp column aligned with the Carrie row "Well, okay… you have to pick the right tool."

	Amy	[reading to herself…] Consider the fact that blacksmiths worked with metal…

	Transcriber	Carrie and researcher try to resolve problem with the pointer
	Amy	Do you want me to do a hint for you?
	Carrie	Sure, If you want to… I want to know where they are in a city…
	Amy	[reading] look for people at a sawmill, and people working with wood.
	Carrie	People working with wood… [she then begins reading aloud then fades to a murmur]… okay, this one looks like it would be mine… so I'm going to put it on here... Got that one... There we go.
0:36:32	Amy	Port Kells...
	Carrie	Oh, I didn't know mort Kells, oh, that's good to know…. You're not having luck with the pointer are you?
	Amy	Easy, just right...
	Carrie	I would say just right… because I did have to look.
	Amy	There are no new tasks.
0:37:27	Transcriber	Explains the problem to the family regarding the pointer device, advises the team to quit the task. The team tries to resolve the problem... They then return to the table to go over the puzzle pieces
	Researcher	**Okay, so Danny gets the reader.**
	Carrie	[reading the task] what was brought… hey, let's read it together Danny.
	Danny	[Reads the task description out loud]
	Carrie	What were those places called?... We are still in the blacksmith right? [she then reads another task aloud that relates to heated metal]...
	Carrie	Okay, I think I know which one that would be.
	Carrie	[now standing in blacksmith area]... Let's pick Danny's task… Amy?...
	Carrie	Don't just pick anyone
0:40:04	Danny	I know
	Carrie	Don't accept it yet… Read it out first
	Amy	[reading task aloud to family]... Do you want a hint?
	Carrie	Sure.
	Amy	[reading aloud] These processing plants are located along the shore.
	Researcher	**Amy, can you do me a favor, can you quit the task for your mom?**
	Researcher	**Yeah, so quit the task.**
	Carrie	What was the hint?
	Danny	It's something along the shores.
	Amy	These processing buildings are located along the shore
	Danny	Here, what's this?
	Carrie	So, it's either this one or this one...
	Danny	I think it's this one... It says... Rivers, boats... I think it's this one.
	Amy	Don't press anything yet.
	Danny	They would bring things along the river, in a boat.
	Amy	No, no, no that one isn't it...
	Carrie	Well, does this one go with this one?

	Amy	No, this one goes with this one.
	Carrie	We have freight and supplies on the river in a boat.
0:42:03	Amy	That has nothing to do with buildings along the shore.
	Danny	Rivers and boats.
	Amy	But this is with that.
	Carrie	You think so?
	Danny	Yeah, I think so.
	Carrie	Okay, so pick one Danny
	Danny	Ohhh... Is there any shores or anything?
	Carrie	So let's read him the question again, he wants to...
	Amy	[sigh]
	Carrie	I don't want to pick it for him.
	Amy	[reading with Carrie... They read the task together]
	Carrie	Like sawmills and stuff, right?
	Carrie	[reading the last part of the task with Amy]
	Carrie	So go to the hint.
	Amy	[she reads the hint out loud]
	Carrie	Did you pick one Danny?
	Carrie	You can either pick this one Danny... Or …
	Danny	I pick this one… I don't really care.
	Carrie	Did it turn blue?
	Danny	Yes.
	Amy	This is the one that you had... Port Kells.
	Correen	Yes but it was also... Was it a blue puzzle?
	Danny	Yes.
	Danny	Well, I guess that is done.
	Amy	But it keeps on going to task info…
	Carrie	That means it's done.
	Amy	No, we have to do the just right, hard…. That's not showing up
	Carrie	You have to push the blue button.
	Amy	It should say review
	Carrie	Let's go ask him.

0:44:59	Transcriber	The family explains the problem with the system… The PDA is messed up… and they proceed to the reward for the blacksmith.

	Carrie	Oh, I was supposed to use the pointer there [referring to something she sees in the video. She then talks to a researcher about other issues with the system]

0:47:10	Transcriber	The instructional part of the video starts.

	Carrie	So you get taught after about the… [becomes inaudible, she periodically talks to researcher about learning, but it's difficult to understand to the video]

213

0:49:01	Danny	Home life.
0:47:10	Transcriber	The intro movie for home life plays.

	Researcher	**Do you want to do that?**
	Carrie	Sure.
	Danny	So I do the monitor right?
	Researcher	**No, you're mom is going to do the monitor.**
	Danny	I wanted to…
	Carrie	Do you want to do the monitor this time? We can switch
	Danny	It's fine, it's fine.
	Researcher	Danny you get the pointer and Amy...
0:49:56	Amy	Cool, I'm in the music industry.
	Carrie	[reads Amy's task to her out loud]
	Amy	Advertise.
	Danny	[reads his own task quietly to himself, but out loud]
	Danny	Where's the home life?
	Researcher	**The home life is here, and the other side, and the living room here, and here…**
	Carrie	So, let's say that you were just starting out, okay? And you came to Surrey and you were all by yourself. And you need to start a business. What would you create?... Okay hold on, don't…. You must select two items and they should relate to the type of business you are trying to open. Use the pointer to complete the task... so what kind of business... do you want to be... a salesman, a piano...
	Amy	That's supposed to be me... Advertising a pop-star… Mom, I got it.
	Carrie	A fireman [helping Danny]
	Danny	I'll take a fireman, but there's no...
	Carrie	Did he say over here too?
	Amy	I think so, I don't know…. Look at mine.
	Danny	I could do the piano.
	Carrie	Or, do you want to be a TV broadcaster, or do you want to work in radio?
	Amy	Can you look on mine already?
0:52:09	Danny	TV…. I got three puzzles.
	Carrie	Do you have to do three things?... Pretend you work in the industry... in the music... What ways would you choose... Choose three items with the pointer.
	Amy	I got one
	Danny	Is that good?
	Carrie	Umm.
	Amy	A radio… I'm looking for a radio.

214

	Carrie	What does a yellow puzzle mean?
	Carrie	[reading the item description to herself for the organ]
	Amy	Hmmm three ways...?
	Researcher	**For you may want the radio in the living room**
	Amy	So, that's the radio?
	Researcher	**That's a juke box...**
	Amy	So that's the radio
	Carrie	[reading to Danny - It's inaudible due to overlapping of voices]
	Coren	yes, we know that so let's press done.
	Danny	Are these also radios?
	Researcher	**Yep**
	Carrie	Did anyone help you?... No... Review...
	Amy	Amazing... Newspaper…. Whoo hoo!
		you have received a new task…. Oh, [now reads a new task to Danny she then explains that task]... That means what product that could be purchased that changed the lives of many people in the family home...
	Carrie	[she then starts reading again]...
	Danny	I need the reader, should I go and get it?
	Carrie	Yes... what example would be how the house changed, when they got TV… when a house got a TV, life changed… okay...
	Amy	I got two.
	Carrie	Go back to Amy...
	Amy	I got two puzzles
	Carrie	[re-reads the task out loud for Amy]
	Amy	[interrupts the reading] I chose a radio, a TV, and I'm looking for a book or a newspaper…. I don't see a newspaper… but I'm not sure if that's a piano book… no that's...
	Carrie	When you selected that... That was the organ.
	Danny	Yeah.
	Carrie	So you're looking for a...
	Amy	A newspaper...
	Danny	Do you think the table will have my task on it?
0:55:40	Carrie	I can go back to yours…. [she then starts reading Danny's task...]
	Amy	Oh, a magazine... Right.
	Carrie	Do you know what a manufactured good is?
	Danny	No.
	Carrie	Something that is made.
	Danny	Ohhhh.
	Carrie	Like a tree isn't made, it's a resource… so you're looking for something that is made, for someone else to use, and then they sell it... Okay.
	Researcher	**So you're looking for a magazine?**
	Amy	A magazine or a newspaper
	Transcriber	[Asks the researchers about Amy's task]
	Carrie	Oh, Amy, I think... Oh, that's a reader... I was going to say 'magazine'
	Amy	Yeah, I know...

	Carrie	[reads Danny's tasks again]
	Researcher	**So you're looking for one more thing... Is it still the pop star?**
	Amy	Yeah...
	Researcher	**What about the records? It's like CDs**
	Amy	Oh... [surprised]
0:57:12	Carrie	Oh, did you find the radio... TV, Record player
	Amy	Ok, click one of these
	Carrie	Review, did anyone help you Amy
	Amy	No.
	Carrie	Did you find the task...
	Amy	Just right.
	Carrie	Okay, so go back to Danny...
	Amy	Can I go back to the table?
	Carrie	Yeah.
	Carrie	Did you get one?
	Danny	No...
	Carrie	Well, a lot of these changed life... once newspapers came out
	Danny	I choosed it.
	Carrie	Okay…. Did anyone help you Danny?
	Danny	No...
	Carrie	Did Danny find the task easy or just…?
	Danny	Just right.

0:58:31	Transcriber	They return to the table and get more tasks.

	Carrie	Amy…. [she then reads Amy's task out loud to her]…what happened in 1940, do you remember?
	Amy	World War?
	Carrie	Pretty much…. So you go look for something that says 1940's and World War two.
	Danny	[reading his task to himself but is unsure of certain word]… natural fibres?
	Carrie	Yeah.
	Danny	[continues reading task]
	Carrie	Remember Grandma, likes to knit?
	Danny	Yeah.
	Carrie	And where does she go get her yarn?
	Danny	Hmm. At the store.
	Carrie	Right, she goes to a store... But back in the olden days were there stores?
	Danny	No.

		No, so you had to raise sheep, you had to cut the sheep for the wool, you had to spin the sheep's wool into yarn. Now you are going to look for something that is called the spinner.... Do you remember what it
	Carrie	looks like?
	Danny	Yup.
	Carrie	Look in the section there.
	Danny	What's my task again?
	Carrie	You're is about … [she then reads the task]
	Amy	Is this it?
	Carrie	[reads didactic in the museum out loud]… so yup.
	Amy	So which one, this one or this one?
		I think either / or… it doesn't matter…. [reading now] - shortages
	Carrie	required them to make... So it's during...
	Amy	Oh, there it is.
		So during the second world war, what happened during the second world war... So you're done…. Okay [reads task for Amy again]… did
	Carrie	anyone help you?
	Amy	No… and easy.
	Carrie	So there's no new tasks... So go back to Danny.
	Danny	I pointed to that
	Carrie	Did you point to it?
	Danny	Is it that thing...?
	Carrie	Come over this way... A little bit more...
	Danny	Got it...
	Carrie	[reads spinning wheel description to Danny]
1:02:24	Danny	Done... No… Easy… This is fun.
	Carrie	Good.
	Transcriber	They return to the table, and the video reward for home life plays. Followed by the instructional video [no audio from participants can be heard]
1:05:10	Transcriber	The researcher escorts the family downstairs for the post-interview

Appendix F: Example Visitor Self Administered Interview Transcripts

Kurio

Case	Family ID: 13
	Transcriber: Kevin Muise
	PARTICIPANTS: Adults: Carrie **/ Children:** Danny, Amy

Family 13 Self Admin		
Time	**Name**	**Transcript**
Recording1	**Transcriber**	
0:00:02	Carrie	Hi, here we have Danny Quinn, and we're gonna ask him some questions about his museum visit. What interested you the most about the museum before your visit?
	Danny	Well, I would say that it's, I didn't know that we were going to use a whole bunch of tools to use, I thought it was gonna be just looking through the museum.
	Carrie	Ok, was the museum visit like you expected or was it different?
	Danny	It was different. Yeah, I thought we'd just look around, but that time-map thing.
	Carrie	Ok. Tell me what you remember about your day at the museum.
	Danny	Umm, I think uh, what we had to do was there was a time map broken and we had to go back to the past and we had to solve clues and all that to get our time-map fixed, working, so you could go back to the present.
	Carrie	What other museum visits do you remember?
	Danny	Uhh, the (???) royal museum in Victoria. Which, I thought it was pretty neat.
	Carrie	Ok, and what was that - was this different in any way?
	Danny	Uhh, yeah, yes, yes, yes it was because there's, you just look around and all that instead of finding a whole bunch of clues, and... That sort of thing.
	Carrie	What did you like about your day at the Surrey museum?
	Danny	Uhh... Hmm... I think it would be, we had to, had to solve all of the, all of those, all those tools, and trying, trying to navigate us back to the present.
0:02:10	Carrie	What part did you like the least?
	Danny	I would say... I... Disliked the, the point, the pointer was not working during it all, but that was OK, that was ok.
	Carrie	Right, right, the pointer had some glitches in it. Yeah.
	Danny	Yeah, it was ok though.
	Carrie	Ok. Did you have any disappointments or frustrations about the day?
	Danny	Umm, still only the pointer, that's all, no other disappointments.

	Carrie	Ok. How do you think we did in solving the Kurio time-map?
		Pretty good, pretty good, uhh, it was interesting, and we didn't, we could do it ourselves instead of someone else navigating, or kind of helping us just um, standing there watching us if anything goes
	Danny	wrong.
	Carrie	Ok, so... Umm, about the map.
	Danny	Yes?
		How were we able to solve... Do you remember what we had to do in
0:03:10	Carrie	order to...?
		Well, well, what we had to do is we had to go through a whole bunch of different stuffs, there was the aboriginals, home life, farming, and
	Danny	all that... Uhh, and yep!
	Carrie	What did we have to do to the map?
		Uhh, we had to make it so whole again so that it worked and when it
	Danny	works we could go back to the present.
	Carrie	Do you remember what made it work?
	Danny	Uhh, tools...? Like we had tools that we...
	Carrie	Yep, and what did the tools help you find?
	Danny	Uhh, the puzzle pieces, and uhh, that...
	Carrie	So when we, so what happened when we got all the puzzle pieces?
		Well, what happened, when we completed the, we completed the one section of the time-map, then, oh, we'd have a different task
	Danny	every time... And...
		Good, all right, going on to the next question. Tell me about what you
	Carrie	did in the aboriginals' activity?
	Danny	Ohh, I would say like, the, canoe was made out of cedar bark.
	Carrie	Ok.
	Danny	And the...
0:04:34	Carrie	Is that what you had to look for, was the canoe?
	Danny	I think so... Ok.
	Carrie	And, what were some of the other activities did we do, that we did?
	Danny	Uh, home life activity.
	Carrie	Ok, so what did you find out about the home-life activity?
		I thought it would be cool... Or something around your home, and I never knew what it was like back then, it was so weird, but so weird,
	Danny	but kind of an awesome feeling too.
	Carrie	Do you remember what you had to find in the home life section?
		Umm, I had to find this bob-yard, this yard-thingy-ma-bob where
	Danny	they, where they put it in and made the yarn with it.
	Carrie	What did it look like?
	Danny	It was like a wheel, sort of.
0:05:24	Carrie	Do you remember what it was called?
	Danny	No, I can't remember.
		Ok... And, let's see what other thing… did we… I think we did the
	Carrie	trades or blacksmith, I can't remember...?
	Danny	I think yeah, I think we did the blacksmith.

	Carrie	Ok, so what did you learn about the blacksmith?
	Danny	Well, I learned that...
	Carrie	What does a blacksmith do?
	Danny	It makes everything metal, with metal stuff, for example, hammers or anvils, or they use anvils.
	Carrie	Fine.
	Danny	And they make anything with stuff that contains metal (???).
	Carrie	Ok, and ok.
	Danny	And... Yeah.
0:06:07	Carrie	Ok, so, are there any things that you saw at the museum that you would like to find out more about?
	Danny	Umm... Hmm.
	Carrie	What else, I mean we didn't have time to see... To go through the whole museum… are there anything else in the museum that you would like to go back to... you might want to...?
	Danny	I would say the forestry and the farming.
	Carrie	Oh, ok, good! What would you tell others like your friends and other families about your day at the museum?
	Danny	I would say, might want to go there, it's pretty fun, it's good to spend a little time with your family, and it's good to get out of the house, and uhh, it's something that you could get, not used to, but have fun.
0:06:52	Carrie	Ok. So, did you have fun using the curio system, the Kurio system, as opposed, Kurio yes, as opposed to just walking around reading things.
	Danny	Yep, I like that you have to find things and it would tell you where it was on the monitor, and if you got it wrong on the table, it would say, it would have the right puzzle piece.
	Carrie	Ok, now, did you think you learned anything about Surrey?
	Danny	Oh yeah, yeah. Umm, man it's so far back I forget.
	Carrie	Yeah, so, since it's so far back and you forgot, maybe we should go back and visit it again sometime...?
	Danny	Yeah, yeah.
	Carrie	All right, that concludes our questions with Danny Quinn.
0:07:43	Danny	Bye, bye!
Recording2	Transcriber	
0:00:00	Carrie	Hi again, this is interviewing Amy about our museum visit. Ok, so question 1 Amy, what interested you about the museum, before our visit?
	Amy	Hmm.
Recording3	Transcriber	
0:00:03	Amy	Pretty much, pretty much nothing.
	Carrie	Were you interested in going to the museum?
	Amy	Sort of.
	Carrie	Ok, have you been to the Surrey museum before?
	Amy	No.
	Carrie	Ok. Was the museum visit like you expected or was it different?

220

	Amy	It was different.
	Carrie	Ok, what did you expect?
	Amy	It wasn't really a museum and reading every single plaque.
	Carrie	Ok, so why was it different?
	Amy	Umm, cause, it was different because you had to use these tools and usually in museums you don't have to use tools.
	Carrie	Ok, so tell me what you remember about that day at the museum? You mentioned about the tools...
	Amy	You used tools...
	Carrie	What kinds of tools? What do you mean by tools?
	Amy	Well, tools to help you look and learn about other stuff.
	Carrie	Ok, what kinda, give me an example?
	Amy	Umm...
	Carrie	What other museum visits can you remember?
	Amy	The Royal BC museum.
	Carrie	And did you like the Royal BC Museum?
	Amy	Yeah, and the only part I remember is like the mammoth.
	Carrie	Ok, so the Surrey museum, what was, why was it different than the Royal museum?
	Amy	Yes.
	Carrie	Yes, so do you, ok, do you why was it different?
0:01:40	Amy	a) it was smaller, and b) you didn't get to use tools in the Royal museum.
	Carrie	What did you like best about the museum, the Surrey museum?
	Amy	Using the tools.
	Carrie	So how did the tools work?
	Amy	Good. Except they kinda didn't really know how to use the listener one.
	Carrie	Was the listener one difficult?
	Amy	Yep.
	Carrie	And how about the monitor?
	Amy	The monitor, it was fine.
	Carrie	What did the monitor do?
	Amy	The monitor, it... it told, if you had a col, if you had an answer or not, and it will talk up and it will, and you can... You can say that it's the right answer, and you can delete it.
	Carrie	Ok. So what part did you like the least about the museum?
	Amy	Mmm.
0:02:40	Carrie	Did you have any disappointments or frustrations?
	Amy	No, I didn't.
	Carrie	Ok, well, what did you like the most?
	Amy	The tools and the nice family hub.
	Carrie	Ok, so we used to the tools to solve the Kurio time-map. How do you think we did that? Tell me how we were able to solve the map using the tools. What was the process?
	Amy	I don't know.

	Carrie	Well, when you went to get... Your monitor gave you a question.
	Amy	Yeah.
	Carrie	And you went to answer the question.
	Amy	Yep.
	Carrie	You had to use the tool. After you've answered the questions, how did you know if you've got the question right or wrong?
	Amy	You kinda match it up with your, the question, and you see if there's any words that match it, sort of the same subject.
	Carrie	So when you used the tool, then what happened on the monitor?
	Amy	Umm... Mmm... I don't know.
0:04:19	Carrie	Ok, so. Tell me what you did in the Aboriginal activity?
	Amy	I had to find questions of how did they heat their home and cook their food, and what their canoe was made of and how they did it.
	Carrie	Ok.
		Ok, and how about the, I think we visited the home life activity, what do you remember about that activity?
	Amy	Um, trying to find the, trying to find three things, to advertise a pop star.
	Carrie	Oh, ok. What were, do you remember what they were?
	Amy	Umm, yes, to advertise a pop star back then, it'd be radio, TV, and a record player. That's pretty much the same except for the record player.
	Carrie	Ok, now what other activity did we see? Do you remember, I'm trying to...
	Amy	Blacksmith.
	Carrie	Oh, ok. Did you enjoy that one? Do you remember any of the questions you had to look at, to look for?
	Amy	No, I don't think. No, I was using the monitor, so I didn't have any questions.
	Carrie	Ok. Did you like using the monitor?
	Amy	Yeah.
	Carrie	Now, how did you use, do you remember how the monitor worked?
0:05:46	Amy	Yeah, you just take this pen thing and you just use buttons.
	Carrie	Ok. And, ok, going on to question 9: are there any things you saw at the museum that you would like to find out more?
	Amy	No!
	Carrie	Ok, we didn't visit the whole museum, we only saw a part of it, would you be interested in going back to the museum and seeing the rest of it...?
	Amy	Umm, I am not sure - if we got to use the tools again, then yeah.
	Carrie	Oh ok...
	Amy	I don't really like walking around...
	Carrie	So would you tell others, like your friends about your day at the museum?
	Amy	Yeah. Yep.
	Carrie	Ok, did you learn anything about Surrey?

	Amy	No!
	Carrie	Ok... What, was there anything there about Surrey?
	Amy	I don't remember.
	Carrie	Ok, well, we didn't really cover the history of Surrey, we were more I guess about the pioneers, and if so, what did this visit make you think most about? What did you think most about?
	Amy	Pardon?
	Carrie	What did you think, what did you remember the most?
	Amy	Ohh, umm, the advertising the pop star, and the Kurio time-map.
	Carrie	Ok, so tell me about the Kurio time-map. That big desk, what did it show us, remember?
	Amy	The time-map.
	Carrie	And what is the time-map.
	Amy	It's how to get back to the present.
	Carrie	Ok.
	Amy	And you had to do all these.
	Carrie	Ok, and how do you note, how do you know when you got back to the present?
	Amy	It tells you?
	Carrie	And how does it tell you (laughs)?
	Amy	It tells you you've completed the time-map.
0:07:46	Carrie	Ok, and so my next question is how do you complete the time-map then?
	Amy	By finding a whole bunch of questions.
	Carrie	And when you answered the question... correctly, what did the, what did the time-map give you?
	Amy	A puzzle piece.
	Carrie	That's right! And so, when you get the puzzle pieces, what happened when you got all the puzzle pieces.
	Amy	It completed a picture of the puzzle piece, and that means that you've completed the section.
	Carrie	Ok, so, that concludes our follow up interview, and hopefully that's the information you need and thank you very much, and bye-bye!
0:08:37	Amy	Bye.
	Transcriber	END

223

Appendix G: CD-ROM Data

The CD-ROM attached forms a part of this work.

Raw Data files were created using QuickTime player, and can be opened in QuickTime player or the iTunes player. Data file can be opened with MS Excel, and Microsoft Word. The PDF file was created with Adobe Acrobat, but may be opened in any PDF program.

Kurio Case Raw Data Files and Transcripts

Name:	Location	Size
Designer Interview 07 Audio	raw data/ kurio case/ designer interviews/ID_07_interview.mp3	3.1 MB
Designer Interview 07 Transcript	Transcripts/ designer interviews/ Kurio Case / interview_participan07.docx	160 KB
Designer Interview 08	raw data/ kurio case/ designer interviews/ID_08_interview.mp3	5.6 MB
Designer Interview 08 Transcript	Transcripts/ designer interviews/ Kurio Case / interview_participan08.docx	168 KB
Family 13 In-Museum Audio	raw data/ kurio case/ family data/ Family 13/ audio files/ in-museum.MP3	79 MB
Family 13 self-admin. Audio	raw data/ kurio case/ family data/ Family 13/ audio files/ self-administered_01.mp3	930 KB
Family 13 in-museum video	Raw data/ kurio case/ family data/ Family 13 / Family_13_video.m4v	637.8 MB
Family 15 In-Museum Audio	raw data/ kurio case/ family data/ Family 15/ audio files/ in-museum.mp3	5.3 MB
Family 15 self-admin. Audio	raw data/ kurio case/ family data/ Family 15/ audio files/ Self-administered_01.mp3	15.4 MB
Family 15 in-museum video	Raw data/ kurio case/ family data/ Family 15 / Family_15_video.m4v	425.7 MB
Family 21 In-Museum Audio	raw data/ kurio case/ family data/ Family 21/ audio files/ in-museum.mp3	8.2 MB
Family 21 in-museum video	Raw data/ kurio case/ family data/ Family 21 / Family_21_video.m4v	649.9 MB

BodyWorks 2 Case Raw Data Files

Name:	Location	Size
Designer Interview 09	raw data/ bodyworks case/ designer interviews/ID_09_interview.mp3	7.2 MB
Designer Interview 10	raw data/ bodyworks case/ designer interviews/ID_10_interview.mp3	5.6 MB
Family 02 In-Museum Audio (Mark's Mic)	raw data/ bodyworks case/ family data/ Family 02/ mark.mp3	4.3 MB
Family 02 In-Museum Audio (Sharon's Mic)	raw data/ bodyworks case/ family data/ Family 02/ sharon.mp3	103.5 MB
Family 02 In-Museum Notes	raw data/ bodyworks case/ family data/ Family 02/ Family_02.doc	53 KB
Family 02 Self-Administered Audio	raw data/ bodyworks case/ family data/ Family 02/ self-administered.AIFF	4.1 MB
Family 04 In-Museum Audio (Amber's Mic)	raw data/ bodyworks case/ family data/ Family 04/ Amber.mp3	4.4 MB
Family 04 In-Museum Audio (Andrew's Mic)	raw data/ bodyworks case/ family data/ Family 04/ Andrew.mp3	4.4 MB
Family 04 In-Museum Audio (Ryan's Mic)	raw data/ bodyworks case/ family data/ Family 04/ Ryan.mp3	4.5 MB
Family 04 In-Museum Notes	raw data/ bodyworks case/ family data/ Family 04/ Family_04.doc	61 KB
Family 04 Self-Administered Audio	raw data/ bodyworks case/ family data/ Family 04/ self-administered.mov	145.1 MB
Family 05 In-Museum Audio (Elizabeth's Mic)	raw data/ bodyworks case/ family data/ Family 05/ Elizabeth.mp3	6.8 MB
Family 05 In-Museum Audio (Mary's Mic)	raw data/ bodyworks case/ family data/ Family 05/ Mary.mp3	7.1MB
Family 05 In-Museum Notes	raw data/ bodyworks case/ family data/ Family 05/ Family_05.doc	45 KB
Family 05 Self-Administered Audio	raw data/ bodyworks case/ family data/ Family 05/ self-administered.AIFF	138.2 MB
Family Visit Notes from Second Researcher	raw data/ bodyworks case/ family data/ Notes_secondResarcher.doc	57 KB

Kurio Case Transcripts

Name:	Location	Size
Designer Interview 07 Transcript	Transcripts/ designer interviews/ Kurio Case / interview_participan07.docx	160 KB
Designer Interview 08 Transcript	Transcripts/ designer interviews/ Kurio Case / interview_participan08.docx	168 KB
Family 13 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Kurio Case / Family_13.docx	176 KB
Family 13 Self-Admin Audio Transcript	Transcripts/ Family Self-Administered/ Kurio Case / Family_13.docx	135 KB
Family 15 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Kurio Case / Family_15.docx	143 KB
Family 15 Self-Admin. Audio Transcript	Transcripts/ Family Self-Administered/ Kurio Case / Family_15.docx	139 KB
Family 21 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Kurio Case / Family_21.docx	180 KB

BodyWorks 2 Case Transcripts

Name:	Location	Size
Designer Interview 09 Transcript	Transcripts/ designer interviews/ Bodyworks Case / interview_participan09.docx	168 KB
Designer Interview 10 Transcript	Transcripts/ designer interviews/ Bodyworks Case / interview_participan10.docx	160 KB
Family 02 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Bodyworks / Family_02.docx	123 KB
Family 02 Self-Admin Audio Transcript	Transcripts/ Family Self-Administered/ Bodyworks Case / Family_02.docx	123 KB
Family 04 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Bodyworks Case / Family_04.docx	139 KB
Family 04 Self-Admin. Audio Transcript	Transcripts/ Family Self-Administered/ Bodyworks Case / Family_04.docx	135 KB
Family 05 In-Museum Audio Transcript	Transcripts/ Family In-Museum/ Bodyworks Case / Family_05.docx	127 KB
Family 05 Self-Admin Audio Transcript	Transcripts/ Family Self-Administered/ Bodyworks Case / Family_05.docx	135 KB

Data Tabulation For Cases

Name:	Location	Size
BodyWorks 2 designer Interview Tabulation	Data tabulation / DesignerInterview_Bodyworks.docx	90 KB
Kurio designer Interview Tabulation	Data tabulation/ DesignerInterview_Kurio.docx	82 KB
BodyWorks 2 Family Visitor tabulation	Data tabulation/ FamilyVisitors_Bodyworks.docx	131 KB
Kurio Family Visitor Tabulation	Data tabulation/ FamilyVisitors_Kurio.docx	123 KB

Protocol Documents

Name:	Location	Size
Designer Interview Questions	Protocol documents / designer_questions.docx	90 KB
Family Visit Protocol	Protocol documents / family_protocol.docx	127 KB
BodyWorks 2 Letter to Participants	Protocol documents / sw_participant_letter.doc	152 KB
Kurio Letter to Participants	Protocol documents / surrey_participant_letter.doc	41 KB
BodyWorks 2 Letter of Permission	Protocol documents / SW_permission.pdf	45 KB

REFERENCE LIST

Archer, L. B. (1984). Systematic method for designers. In N. Cross (Ed.), *Developments in Design Methodology (pp.57-84)*. Bath, UK: Pitman.

Bares, W., Zettlemoyer, L., & Lester, J. (1998). Habitable 3D learning environments for situated learning. *Proceedings of the 4th International Conference on Intelligent Tutoring Systems*, *United States*, 16-19.

Bailey, E., Bronnenkant K., Kelley, J., & Hein G. (1998). Visitor Behavior at a Constructivist Exhibition: Evaluating Investigate! at Boston's Museum of Science. In C. Dufresne-Tassé (Ed.), *Evaluation and Museum Education: New Trends* (pp. 149-168). Montreal, QB: ICOM/CECA.

Bereiter, C. (1994). Constructivism, socioculturalism, and Popper's World 3. *Educational Researcher,* 23(7): 21-23.

Bijl, A. An Approach to design theory. (1987). In H. Yoshikawa and E.A. Warman (Eds.), *Design Theory in CAD* (pp.3-5). Amsterdam: North Holland.

Black, G. (2006*). The Engaging Museum: Developing Museums for Visitor Involvement.* Abingdon, UK: Routledge.

Blyth, A., & Worthington, J. (2000). *Managing the brief fro better design*. New York, NY: Routledge.

Chayutsahkij, P. (2002). *User-centered design goal setting: The interplay between user research and innovation* (Doctoral dissertation). Graduate College of Illinois Institute of Technology, Chicago, IL.

Chen, Y-S., Kao, T-C., Yu, G-J., & Sheu, J-P. (2004). A mobile butterfly-watching learning system for supporting independent learning. *Proceedings of the 2nd International Workshop on Wireless and Mobile Technologies in Education*. *Taiwan*, 11-18.

Chiari, G., & Nuzzo, L. (1993). Personal construct theory within psychological constructivism, precursor or avant-gard. *Proceedings of the Tenth International Congress of Personal Construct Psychology*, *Australia*, July 12-17.

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

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

Creswell, J. W. (1994). *Research design: Qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Dix, A., Finlay, J., Abowd, G., & Beale, R. (2004). *Human-Computer Interaction* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Dorst K. (2004). On the problem of design problems – problem solving and design expertise. *Journal of design research*, 4(2). Retrieved January 23, 2010, from http://www.inderscience.com/jdr/backfiles/articles/issue2004.02/Art5.html

Duffy, T.M., & Savery, J.R. (1994). Problem-based learning: An instructional model and its constructivist framework. In Wilson, B. (Ed.) *Constructivist learning environments: Case studies in instructional design*. (pp 135-146). Englewood Cliffs, NJ: Educational Technology Publications.

Economou, M. (2007). A world of interactive exhibits. In Marty, P. & Jones, K. (Eds.) *Museum Informatics.* (137-156). London, UK: Routledge.

Easterbrook, S., Yu, E., Aranda, J., Fan, Y., Horkoff, J., Leica, M., & Qadir, R.A. (2005). Do viewpoints lead to better conceptual models? An exploratory case study, *Proceedings of the 13th IEEE International Conference on Requirements Engineering. France*,199-208.

Feagin, J., Orum, A., & Sjoberg, G. (Eds.). (1991). *A case for case study*. Chapel Hill, NC: University of North Carolina Press.

Forlizzi, J., & Battarbee, K. (2004). Understanding experience in interactive systems. *Proceedings of the 5th conference on Designing interactive systems*, *USA,* 261-268.

Forlizzi, J., Ford, S. (2000). The Building Blocks of Experience: An Early Framework for Interaction Designers. *Proceedings of the 2nd conference on Designing Interactive Systems*, *USA*, 419-423.

Fostnot, C. T. (Ed.). (2005). *Constructivism Theory, perspectives and Practice*. New York, NY: Teachers College Press.

Fostnot, C.T. & Perry, R. S. (2005). Constructivism: A Psychological Theory of Learning. In Fosnot, C. T. (Ed.), *Constructivism Theory, perspectives and Practice* (pp. 8-33). New York, NY: Teachers College Press.

Griffin, J., Kelly, L., Savage, G., & Hatherly, J. (2005). Museums actively researching visitor experiences and learning (MARVEL): a methodological study. *Open Museum Journal*, 7. Retrieved January 23, 2010, from http://hosting.collectionsaustralia.net/omj/vol7/griffin.html

Griffiths, A. (2002). Museums for the 21st Century: entertainment or big challenging ideas? *Artlink,* 22(4), 16-22.

Hadjerrouit, S. (2005). Constructivism as Guiding Philosophy for Software Engineering Education. *ACM SIGCSE Bulletin*, 37(4), 45-49.

Harfield, S. (2007). On design 'problematizaton': Theorizing differences in designed outcomes. *Design Studies*, 28(2), 159-173.

Hatala, M., Tanenbaum, K., Wakkary, R., Muise, K., Mohabbati, K., Corness, G., Budd, J., & Loughin, T. (2009)**.** Experience Structuring Factors Affecting Learning in Family Visits to Museums. In Proceedings of *EC-TEL,* Italy, 37-51.

Hein, G. (1998). *Learning in the Museum*. London, UK: Routledge.

Hein, H. (1990). *The Exploratorium: The Museum as Laboratory.* Washington, DC: Smithsonian Institution.

Henning, M. (2006). *Museums, Media and Cultural Theory*. Berkshire, UK: Open University Press.

Höök, K. (2006). Designing familiar open surfaces. *Proceedings of the 4th Nordic conference on Human-computer interaction. Norway*, 242-251.

Hornbæk, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human-Computer Studies*, 64, 79-102.

Hornbæk, K., & Law, E. (2007). Meta-Analysis of Correlations Among Usability Measures. *Proceedings of CHI '07* (pp. 617-626). New York: ACM Press.

Jacko, J., & Sears, A. (Eds.). (2003). *The Human-computer Interaction Handbook.* Mahwah, NJ: Lawrence Erlbaum Associates.

Kafai, Y. & Resnick, M. (1996). Introduction. In Y. Kafai & M. Resnick (Eds.), *Constructionism in Practice: Designing, Thinking and Learning in a Digital World* (pp. 175-206). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Krippendorff, K. (2007). Design Research, an Oxymoron? In Mitchell, R. (Ed.), *Design Research Now* (pp. 67-80)*.* Basel: Birkhauser.

Mahlke, S. (2008). *User experience of interaction with technical systems* (Doctoral dissertation). Berlin University of Technolog, Berlin, GER.

Maxwell, J.A. (Ed.). (2005). *Qualitative research design: An interactive approach* (2nd ed.). Thousand Oaks, CA: Sage.

McCarthy, J., & Wright, P. (2004). *Technology as experience*. Cambridge, MA: MIT Press.

Merriam, S.B. (1998). *Qualitative Research and Case Studies Applications in Education*. San Francisco, CA: Jossey-Bass Publications.

Message, K. (2006). *New Museums and the Making of Culture*. New York, NY: Berg.

Morrison, D. (2003). Using activity theory to design constructivist online learning environments for higher order thinking: A retrospective analysis. *Canadian Journal of Learning and Technology*, 29(3). Retrieved January 23, 2010, from http://www.cjlt.ca/index.php/cjlt/article/viewArticle/87/81

Naismith, L., Lonsdale, P., Vavoula, G., & Sharples, M. (2004). Literature Review in Mobile Technologies and Learning. *NESTA Futurelab Series*, Report 11.

Nielsen, J., & Levy, J. (1994). Measuring usability: Preference vs. performance. *Communications of the ACM*, 37(4), 66-75.

Norman, Donald A, & Draper, S. (Eds.). (1986). *User Centered System Design: New Perspectives on Human-Computer Interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Liaw, S. S. (2005). Developing a Web assisted knowledge construction system based on the approach of constructivist knowledge analysis of tasks. *Computers in Human Behavior*, 21(1), 29-44.

Lindström, M., Staahl, A., Höok, K., Sundström, P., Laaksolathi, J., Combetto, M., Taylor, A., & Bresin, R. (2006). Affective diary: designing for bodily expressiveness and self-reflection. In Proceedings of *CHI '06: CHI '06 extended abstracts on Human factors in computing systems*, *USA,* 1037-1042.

Petrelli, D., & Not, E. (2005). User-centered design of flexible hypermedia for a mobile guide: Reflections on the hyperaudio experience. *User Modeling and User-Adapted Interaction*, 15, 3 - 4.

Pena, W.M.(1969). *Problem Seeking*. Houston:TX:Caudill Rowlett Scott.

Piaget, J., & Inhelder, B. (1969). *The psychology of the child.* New York, NY: Viking.

Persson, P., Espinoza, F., & Cacciatore, E. (2001). GeoNotes: social enhancement of physical space, *In Proceedings of CHI '01: CHI '01 extended abstracts on human factors in computing systems*, *USA,* 43-44.

Preece, J., Rogers, Y., & Sharp, H. (2002). *Interaction Design: Beyond Human-Computer Interaction*. New York, NY: John Wiley & Sons.

Read, J.C., & MacFarlane, S. (2006). Using the Fun Toolkit and Other Survey Methods to Gather Opinions in Child Computer Interaction. *In Proceedings of the international conference for Interaction Design and Children*, *Finland,* 81-88.

Reeve, J., & Woollard, V. (2006). Influences on Museum Practice. In C. Lang, J. Reeve & V. Woollard (Eds.), *The Responsive Museum: Working with Audiences in the Twenty-First Century* (pp. 3-5). Hampshire, UK: Ashgate.

Reitman, W R. (1964). Heuristic decision procedures, open constraints, and the structure of ill-defined problems. In M. W. Shelly and G. L. Bryan (Eds.) *Human Judgements and Optimality* (pp. 669-690). New York, NY: Wiley.

Rittel, H. W. J.,& Webber, M. (1984). Planning Problems are Wicked Problems. In Cros, N. (Ed.), *Developments in Design Methodology* (pp.57-82), Bath: Pitman Press.

Roussou, M. (2004). Learning by doing and learning through play: an exploration of interactivity in virtual environments for children, *Computers in Entertainment*, 2(1), 10.

Roschelle, J. (1995). Learning in interactive environments: Prior knowledge and new experience. In J. H. Falk & L. D. Dierking (Eds.), *Public institutions for personal learning: Establishing a research agenda* (pp. 37-51). Washington, DC: American Association of Museums.

Rowe, P. (1987). *Design Thinking*. Cambridge: MA: MIT Press.

Ståhl , A., & Höök, K. (2008). Reflecting on the design process of the affective diary. *Proceedings of the 5th Nordic conference on Human-computer interaction. Sweeden*, 559-564.

Scrivener, S. A. R., Liang, K. C., & Ball, L. J. (2002). Extending the design problem-solving process model: Requirements and outcomes. *Proceedings of the International Conference of the Design Research Society. UK,* Retrieved: January 20, 2010, from http://eprints.lancs.ac.uk/11139/

Shaw, A. (1996). Social constructionism and the inner city. In Y. Kafai & M. Resnick (Eds.), *Constructionism in Practice: Designing, Thinking and Learning in a Digital World* (pp. 175-206). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Simon, H. (1996). *Science of the Artificial*. Cambridge, MA: MIT Press.

Simon, H. (1984). The Structure of Ill Structured Problems. In Cros, N. (Ed.), *Developments in Design Methodology* (pp.57-82), Bath, Pitman Press.

Stake, R. (1995). *The art of case research*. Newbury Park, CA: Sage Publications.

Sterry, P., & Beaumont, E. (2006). Methods for Studying Family Visitors in Art Museums: A Cross-Disciplinary Review of Current Research. *Museum Management and Curatorship,* 21, 222-239.

Von Glasersfeld, E. V. (2005). Introduction: Aspects of Constructivism. In Fosnot, C. T. (Ed.), *Constructivism Theory, perspectives and Practice* (pp. 3-7). New York, NY:Teachers College Press.

Vrasidas, C. (2000). Constructivism versus objectivism: Implications for interaction, course design, and evaluation in distance education. *International Journal of Educational Telecommunication*, 6(4), 339-361.

Vygotsky, L.S. (1978). *Mind and society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Waite-Stupiansky, S. (1997). *Building Understanding Together : A Constructivist Approach to Early Childhood Education*. Albany., NY: Delmar Publishers.

Wakkary R, & Hatala M. (2006). Ec(h)o: Situated play in a tangible and audio museum guide. *Proceedings of Designing Interactive Systems*, *UK*, 281-290.

Wakkary, R., Muise, K., Tanenbaum, K., Hatala, M., & Kornfeld, L. (2008). Situating Approaches to Museum Guides. *Museum Management and Curatorship*, 23(24), 367-383.

Walsh, V., Roy, R., Bruce, M., & Potter, S. (1992). *Winning by design: technology, product design, and international competitiveness*. Oxford, UK: Blackwell Business.

Wertsch, J.V. (1997). *Vygotsky and the formation of the mind*. Cambridge, MA: Blackwell publishers.

Whiteside, J., Bennett, J., and Holtzblatt, K. (1988). Usability Engineering: Our Experience and Evolution. In M. Helander (Ed.), *Handbook of Human-Computer Interaction* (pp. 791-804). North Holland: Elsevier Science Publishers.

Whiteside, J., & Wixon, D. (1987). The Dialectic of Usability Engineering. In Bullinger, H-J, & Shackel, B. (Eds.), *International Conference on Human-Computer Interaction* (pp. 17-20.). Amsterdam: Elsevier.

Winterbottom, C., & Blake, E. (2008). Constructivism, virtual reality and tools to support design. *Proceedings of the 7th ACM conference on Designing Interactive Systems*. *South Africa*, 230-239.

Witcomb, A. (2003), *Re-imagining the Museum: Beyond the Mausoleum*, London, UK: Routledge.

Yin, R. (2003). *Case study research: Design and methods.* (3rd Ed.). Thousand Oaks, CA: Sage Publishing.

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers and Education*, 42, 289-314.