Approval

Name: Brendan Matkin
Degree: Master of Arts
Title: ʔeləw̓kʷ – Belongings: Embodied Cultural Values in Tangible Interaction Design

Examiner Committee: Chair: Gabriela Aceves-Sepulveda
Assistant Professor

Alissa Antle
Senior Supervisor
Professor

Kate Hennessy
Supervisor
Associate Professor

Will Odom
External Examiner
Assistant Professor

Date Defended/Approved: April 10, 2018
**Ethics Statement**

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

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or

b. advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University

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Abstract

In this thesis through an exploratory study I investigate the ways that an interactive tangible tabletop about aboriginal heritage enabled museum visitors to experience intangible cultural values. Belongings is a tangible tabletop that uses replicas of ancient and modern belongings of the Musqueam people to interact with digital activities and content. I situate my research by describing the system and a previous study that lead to the redesign of the tabletop. I then describe the field interview methodology for my study that took place at the Museum of Anthropology (UBC) with 20 visitors. Based on thematic analysis of responses, I present 10 themes, from which I derive design guidelines for tangible tabletop design for intangible culture heritage. Guidelines highlight the importance of the fidelity of replicas, breaking museum practices and using objects that visitors can relate to in order to enable visitors to experience aboriginal values through tangible interaction.

Keywords: tangible interaction; embodied interaction; cultural values; intangible heritage; tabletop
Dedication

To my family; especially my incredibly long-suffering wife, Jessica.
Acknowledgements

Special thanks to Susan Rowley and Jordan Wilson whose incredible curatorial talents made this project so successful. I am also very thankful for the help, advice and support of my thesis supervisor Kate Hennessy. Thanks also to the rest of the team: Rachael Eckersley, Perry Tan, and Lisa Uyeda. A huge thanks to Reese Muntean for all of her support, help interviewing participants, and help analyzing data.

I could not have done this work without the help, guidance, and support of my senior supervisor Alissa Antle. She has been incredibly patient and caring, but has kept a fire lit under me. Thank you Alissa!
Table of Contents

Approval........................................................................................................ ii
Ethics Statement.......................................................................................... iii
Abstract....................................................................................................... iv
Dedication..................................................................................................... v
Acknowledgements...................................................................................... vi
Table of Contents......................................................................................... vii
List of Tables............................................................................................... x
List of Figures ............................................................................................. xi
List of Acronyms ........................................................................................... xii

Chapter 1. Introduction .................................................................................. 1
  1.1. Overview................................................................................................ 1
  1.2. Research Goals..................................................................................... 5
  1.3. Thesis Guide.......................................................................................... 6

Chapter 2. Background ................................................................................... 7
  2.1. Paper: Designing Cultural Values into Interaction (CHI 2017)............. 8
  2.2. Problems and Limitations of the First Prototype................................. 9
  2.3. Exploring Deeper through New Research Questions.......................... 10

Chapter 3. System Design / UI Revisions.................................................... 12
  3.2. What's New: UI Revisions ................................................................. 14
      3.2.1. UI Problem – How to begin....................................................... 15
            Solution....................................................................................... 15
      3.2.2. UI Problem – Matching Activities.......................................... 16
            Solution A (Understand It) – Hint Cards + Hotspot Indicators ....... 16
            Solution B (Teachings) – Hint Cards + Dock Hints + Fade .......... 17
      3.2.3. UI Problem – Recognizing Success......................................... 18
            Solution A (Understand It)......................................................... 18
            Solution B (Teachings)............................................................. 19
      3.2.4. UI Problem – Doing the Right Thing the Wrong Way............... 19
            Solution A (Understand It)......................................................... 20
            Solution B (Teachings)............................................................. 20
      3.2.5. UI Problem – Understanding & Tracking Progress................... 21
            Solution....................................................................................... 21
      3.2.6. UI Problem – Poor Touch Response ....................................... 21
            Solution A: Rebuild .................................................................. 22
            Solution B: Side-effect.............................................................. 22

Chapter 4. Methodology ............................................................................... 23
  4.1. Study Design....................................................................................... 23
  4.2. Participants.......................................................................................... 26
Chapter 5. Results.................................................................................................................. 38
  5.1. Analysis Summary........................................................................................................ 38
  5.2. RQ1................................................................................................................................. 38
      5.2.1. Accuracy + detail of [ancient] belongings......................................................... 38
      5.2.2. Presentation/Context of Belongings................................................................. 39
      5.2.3. Physical Contact/Handling.............................................................................. 40
      5.2.4. Everyday Objects [as Belongings].................................................................... 41
      5.2.5. Contrast of Ancient and Modern.................................................................... 42
  5.3. RQ2................................................................................................................................. 44
      5.3.1. Multiple Pathways............................................................................................... 44
      5.3.2. Challenging Visitors......................................................................................... 45
      5.3.3. Incremental Layers............................................................................................ 46
      5.3.4. Quick Access.................................................................................................... 48
      5.3.5. Belonging (artifact) as Tangible Interface....................................................... 49
  5.4. Interesting ..................................................................................................................... 50
  5.5. Limitations.................................................................................................................... 52
      5.5.1. Limitations of the Belongings System............................................................... 52
      5.5.2. Limitations of Study Design........................................................................... 53

Chapter 6. Discussion............................................................................................................. 55
  6.1. Preliminary Findings...................................................................................................... 55
      6.1.1. Everyday Objects............................................................................................... 55
      6.1.2. Fidelity of Replicas to the Original Belongings.............................................. 57
      6.1.3. Breaking Social Practices.............................................................................. 58
      6.1.4. Ancient-Modern Contrast ............................................................................. 61
  6.2. Established Findings..................................................................................................... 62
      6.2.1. Quick Access...................................................................................................... 63
      6.2.2. Multiple Pathways ......................................................................................... 64
      6.2.3. Incremental Layers for Meaning .................................................................... 66
      6.2.4. Challenging Visitors ....................................................................................... 67
  6.3. Design Guidelines........................................................................................................ 68

Chapter 7. Conclusions .......................................................................................................... 71
  7.1. Summary....................................................................................................................... 71
  7.2. Future Work.................................................................................................................... 72
7.3. Contribution ............................................................................................................................................ 73
References .......................................................................................................................................................... 76
Appendix A. CHI Paper: *Designing Cultural Values into Interaction* (CHI 2017) .............................................. 83
Appendix B. DIS Paper: *Design Interactions in Ḫelawkʷ – Belongings* (DIS 2016) ........................................... 97
Appendix C. Study Materials ......................................................................................................................... 111
List of Tables

Table 1 - Alignment Chart ................................................................................................................. 31
List of Figures

Figure 2.1  Timeline of Previous Work (with Publications).......................................................8
Figure 3.1  Printed Info Card.....................................................................................................15
Figure 3.2  Ring Hint – Place a Belonging...............................................................................16
Figure 3.3  Hint Cards – Understanding It...............................................................................17
Figure 3.4  Dashed Outline Hint – Understanding It .................................................................17
Figure 3.5  Matching-Dock Hints – Teachings.......................................................................18
Figure 3.6  tǝmǝ-ɬ-toned Salmon with Outline – Understand It ...............................................19
Figure 3.7  Greyscale Salmon – Understand It..........................................................................20
Figure 3.8  Having Stories Reference Card............................................................................21
Figure 4.1  Belongings System – Exhibit Setup....................................................................29
Figure 4.2  Belongings Exhibit Context ..................................................................................30
Figure 4.3  Structured Observation Recording .....................................................................36
**List of Acronyms**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFU</td>
<td>Simon Fraser University</td>
</tr>
<tr>
<td>UBC</td>
<td>University of British Columbia</td>
</tr>
<tr>
<td>TUI</td>
<td>Tangible User Interface</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>UX</td>
<td>User Experience</td>
</tr>
<tr>
<td>MOA</td>
<td>Museum of Anthropology</td>
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Chapter 1.

Introduction

1.1. Overview

As computational systems become increasingly ubiquitous, museums are implementing interactive and digital technologies more and more. Interactive technologies provide opportunities to explore new ways to communicate tangible and intangible cultural heritage with the general public.

Intangible cultural heritage includes, “the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage” (UNESCO, 2003). The protection of tangible and intangible cultural heritage can maximize the vitality, values, and functions of the objects or concepts for the benefit of museum visitors, both now and in the future. (Szmelter, 2013). However, representations of intangible cultural heritage are difficult to portray, which also makes preserving them difficult (Kurin, 2004). The preservation and care of intangible cultural heritage is a current design problem, and there is a significant gap in the research dedicated to its preservation (Bonn, Kendall, & McDonough, 2016).

One important aspect of intangible heritage is cultural values. Values can be undermined or promoted by intentionally designed interactive systems (Friedman, 1996). One approach to the consideration of values in interactive systems is Value Sensitive Design (VSD). VSD is a set of methods to help designers and researchers consider the values of various stakeholders throughout the design process (Friedman, Kahn, Borning, & Hultgren, 2013). Generally, in VSD, stakeholders are considered to be groups such as end-users, researchers, designers, developers etc. Designers may use one or many VSD methods to attempt to design systems that embody universal values or avoid embedded bias (Friedman, 1996). However, in recent years, VSD researchers have suggested focusing on culturally specific values over universal values, as trying to fit all value considerations into universal frames in varying contexts is not always best practice (or even possible). This is a way of applying VSD as a “methodological instantiation of a
particular set of values” (Bornig & Muller, 2012). However, significant emphasis is placed on the values of active stakeholders. One remaining question within a VSD context that doesn’t seem to be addressed by any version of suggested design and evaluation methods is, “What design considerations might affect how end-users experience third-party values?” Therefore, although it contains many methods for the design of interactive systems with considerations for the values of active stakeholders, it may not be the best technique for evaluating embodied intangible heritage in tangible interaction.

However, there are other techniques. To paraphrase from my contribution to the draft of (Muntean et al., 2017): researchers have shown that designers can leverage modern, evolving technologies and media in order to enable visitors to encounter and interact with tangible and intangible cultural heritage. This can include, culturally produced meanings, values, artifacts, settings, as well as a sense of belonging, identity, and culture. Mixed-media interactions with intangible cultural heritage can help to pace participation, legitimise personal accounts, and promote a sense of ownership (Giaccardi & Palen, 2008). Multimodal interaction can allow users to explore tangible and intangible cultural heritage together. There are a number of examples of designers and curators collaborating with Indigenous communities on multimodal projects that allow for archiving, storytelling, and interacting with cultural heritage (e.g. (Eva Hornecker, Marshall, & Rogers, 2007; Shankar & Hooee, 2013)).

Researchers have also shown that engaging with cultural objects is important for knowledge, understanding, and learning. They have discussed how knowledge is embodied within objects and how the generation of new knowledge requires us to engage with them. However, this engagement requires intention and interpretation (J Waddington & Wakkary, 2018; Srinivasan, Boast, Furner, & Becvar, 2009). Tangible interaction allows designers to create bridges between the digital and physical world to assist in the interpretation of, or augment the meaning of physical objects. Many tangible systems use realistic objects with abstract or metaphorical relationships to digital components (A. N. Antle, Bevans, Tanenbaum, Seaborn, & Wang, 2011). Tangibles can also relate physical ideas or concrete examples to intangible ideas (Bakker, Antle, & Van Den Hoven, 2012). Researchers have demonstrated that designers can evoke familiar cultural forms (physical forms, patterns of activity, social practices) in tangible interaction as a means to tap into users’ cognitive, physical, and emotional resources to create
meaningful experiences (M. S. Horn, 2013; Saxe, 2015). Some studies have even suggested using real artifacts as tangible objects, where the original object becomes an interface through which visitors can explore and connect with cultural heritage. Despite often being found behind glass, real artifacts still invoke a sense of awe and wonder in museum visitors (Ciolfi & Bannon, 2002; E. Hornecker, 2008).

A common application of multimodal tangible interfaces is through interactive tangible tabletops. Tangible tabletops combine tangible objects with a large touch screen (i.e. a category of multimodal interaction), and are considered a good fit for museums. They afford multiple users, and can allow designers to focus on content over technology (E. Hornecker, 2008). Adding tangibles to interactive tabletops allows for tight digital-physical coupling, along with incorporating many benefits of physical objects. Tangible tabletops can be designed to support reflection, emotional learning, meaning making, discovery, dialogue and sense-making (A. N. Antle & Wise, 2013; E. Hornecker, 2008). Tangible systems also support many learning theories, including constructivist perspectives where users incrementally build knowledge through real-world experiences and interaction with the world (Ackermann, 1996; A. N. Antle & Wise, 2013).

One interesting technique for communicating values using tangible tabletops is through emergent dialogue (A. Antle, 2014). Researchers suggest that this might be a useful method to use interactive systems to persuade users to talk about their own values which can contribute to changes in opinion, attitude, or behaviour (A. N. Antle, Tanenbaum, Macaranas, & Robinson, 2014). Experimental studies have showed that tangible tools can support users in discussing their ideas and values in order to collaborate effectively in an exploratory interactive installation (Wise, Antle, & Warren, 2017). They have also showed that certain tangible tools can help users to have more in-depth discussions about their values (Wise et al., 2015). These studies demonstrate that emergent dialogue can be a useful model for tangible systems in museum environments.

Another important area of research in tangible tabletops is Entry and Access. Entry points are the parts of an installation that are quickly visible and accessible to visitors – these draw people in, remove barriers, and give an overview of the system. Access points allow users to join quickly and easily, and participate in shared activities (Eva Hornecker et al., 2007). As a precursor to that work, researchers have also studied
how embodied facilitation and constraints (Eva Hornecker & Buur, 2006) can be used to support and direct group processes in tangible systems.

Intuitively, this would suggest that easy, exciting, and/or fun interactions are preferable for museum installations. However, some researchers have suggested that slow interactions can stimulate visitors and make parts of the system more meaningful (Grosse-Hering, Mason, Aliakseyeu, Bakker, & Desmet, 2013). This does not necessarily mean designing interactions that are quantitatively slow; rather, it suggests leveraging interactions that have a sense of dwell time to promote moments of reflection (Hallnäs & Redström, 2001). This can help visitors to engage with uncomfortable content, reveal otherwise overlooked content/experiences, and induce reflection and/or contemplation (Halbert & Nathan, 2015). One technique for designing slow interactions is to exploit uncertainty. This can be done by leveraging or creating intentionally ambiguous information or relations in the system (Gaver, Beaver, & Benford, 2003).

*Theoretical* researchers have suggested that there may be a variety of techniques to embed and embody intangible cultural values within tangible systems (Duranti, Spallazzo, & Trocchianesi, 2016). While there are many individual methods for employing, leveraging, and teaching individual and cultural values in interaction, there is a research gap at the synergetic intersection of several concepts. In this thesis, I demonstrate how designers might leverage and augment several existing and validated design techniques in order to embody intangible cultural values in tangible interaction. I show how designers can use interactive tangible tabletops as multimodal interaction to help visitors experience tangible and intangible cultural heritage together. I show how designers can use realistic cultural forms which are also (apparently) real artifacts to bridge concrete and abstract ideas to create meaning. I explore how designers can leverage slow and ambiguous interactions to augment the experiences and values visitors are experiencing through reflection. Finally, I suggest how designers might use ideas based on emergent dialogue to get users to experience values instead of engaging values through dialogue.

In this thesis, I build on a recent study that I was involved in, and was a co-author for, that resulted in several publications. The main publication from that research that is relevant to this thesis is (Muntean et al., 2017), in which we investigated if our design strategies enabled users “to directly experience cultural values while they interact with
Indigenous knowledge using a tangible tabletop system”. That study resulted in six design recommendations (Muntean et al., 2017). My work, detailed in this thesis, stems from two new research questions that I developed in response to that study (see section 1.2), in order to further evaluate the project design decisions and produce more specific design guidelines. This work includes the redesign of the same interactive tangible tabletop system, based on the results of the previous study (Muntean et al., 2017). The main contribution is a new field study with the revised system. Findings from this study contained some new themes and some themes similar to previous works. Most importantly, the findings were used to derive more specific design guidelines about how to design to support visitors to experience values through interaction than was possible in the previous study. Four of these guidelines are duplicated from previous works and are directly actionable. The other four are new, or contextually specific, and merit further research before being considered generalizable and directly actionable. Overall, the new study resulted in eight detailed design guidelines that designers can use to embody cultural values in tangible interaction.

This thesis built upon, and was only possible because of a unique opportunity for close collaboration between curators, community members, administrators, designers, and researchers, that grew out of long-term and established relationships. Some specific groups include, but are not limited to, the Museum of Anthropology at UBC, the Making Culture Lab at SFU, the TECI Lab at SFU, and the Musqueam Indian Band. None of this research would have happened without the combined efforts of many experts over many years.

1.2. Research Goals

The research in this thesis addresses the following questions:

Research Question 1 (RQ1):

What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

Research Question 2 (RQ2):
What are the important physical-digital relations in the system that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

The remainder of this document details my efforts to address the above research questions, including: related work, methodology, study data and data analysis, findings, and the resulting design guidelines.

1.3. Thesis Guide

This chapter is an introduction to my thesis work. Chapter 2 covers the first design iteration and study of the system evaluated in this work, why it needed a second revision and study, and a comparison of research questions between the two. Chapter 3 details the design of the system being evaluated, and which changes were made between the first and second iterations. Chapter 4 covers the study design, including: participant selection and recruiting, details about data collection and interviews, and data analysis techniques. Chapter 5 details the analysis results, including emergent design themes and limitations of the system as a research artifact. Chapter 6 discusses the implications of the results from chapter 5 as eight distinct findings, situations them within the existing body of work, and presents them as Design Guidelines. Chapter 7 summarizes the findings and contributions, and suggests ideas for future work.
Chapter 2.

Background

This work was primarily motivated by the results of a previous study (Muntean et al., 2017) that we conducted using an earlier version of the system (described in Chapter 3). I worked closely with Reese Muntean (SFU), the project manager, to develop the installation and conduct the study. The core design team also included Perry Tan (SFU, software developer), and Rachael Eckersley (SFU, designer, in charge of the belongings). Other project members included Dr. Kate Hennessy (SFU, Director - Making Culture Lab), Dr. Alissa Antle (SFU, Director - TECI Lab), Lisa Uyeda (MOA, Graphic Design), Dr. Susan Rowley (UBC/MOA, Co-Curator), and Jordan Wilson (UBC/MOA, Co-Curator).

My contributions included: interaction design (wire-framing, prototyping, user scenarios, user interface design, user experience design), digital assets (managing all software assets, designing & creating interface graphics), software development (assisting Tan, researching solutions, coordinating software requirements), system testing (iterative evaluation of software, software-hardware interactions, local network behaviors), study design (developed study protocol, assisted writing interview questions, wrote questionnaire), conducted study (observed and interviewed participants on-site with Muntean), data analysis (one of three researchers to conduct independent, open-coded analysis of interview data), and writing (small part; mainly documenting previous work). Apart from that, I participated in the committee who developed the overall design goals and research questions.

The curators at MOA originally intended to explore social practices in museums through the use of everyday belongings in the system (Muntean et al., 2017) (see 6.1.1, 6.1.3). It is also important to understand some of the context that motivated the exhibit that this system was part of. čəsnaʔem – commonly known as Eburne Site, Marpole Midden, or Great Fraser Midden – is an ancient Musqueam village and cemetery upon which part of modern day Vancouver is built. Around 2000 years ago, it was one of Musqueam’s largest villages, and existed for some thousands of years before that. Amateur archaeologists, the general public, and looters have removed many thousands
of belongings from the ground at ćəsnaʔəm. The development of ʔeləw̓kw — Belongings (the Belongings System) has roots in a paradigm shift in North American museology focused on building new relationships with First Peoples (Muntean, Hennessy, Antle, Rowley, Wilson, Matkin, et al., 2015).

This project was part of a larger exhibit about ćəsnaʔəm which was spread across multiple sites. It was created as a partnership between the Musqueam Indian Band, the Museum of Anthropology at UBC, the Museum of Vancouver, and the University of Waterloo. The MOA exhibition, where this project was installed, shared Musqueam values and worldview using media-rich installations and told about them from the point of view of named Musqueam community members. MOA and Musqueam have long had an existing relationship before this project started, which includes Musqueam’s right to “maintain, control, protect and develop their cultural heritage, traditional knowledge and traditional cultural expression” (“MOA - About,” n.d.; Muntean, Hennessy, Antle, Rowley, Wilson, Matkin, et al., 2015).

There have also been several previous publications as a direct outcome of the project (see Figure 2.1). These writings provide significant context for this thesis, especially about the collaborative design process surrounding this work.

<table>
<thead>
<tr>
<th>Before Project</th>
<th>Design Phase 1</th>
<th>Evaluation 1</th>
<th>Design Phase 2</th>
<th>Evaluation 2</th>
<th>Future Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing relationship between MOA and Musqueam</td>
<td>First version of system</td>
<td>First study Aug 2015</td>
<td>System re-design Aug 2015 - Jan 2016</td>
<td>Second study Jan 2016</td>
<td>Ongoing. MOA will likely extend this work into other domains/media.</td>
</tr>
</tbody>
</table>

*EVA Paper (Muntean et al., 2015) (Collaborative Process)*
*CTAM Article (Muntean et al., 2015) (Collaborative Process)*
*MRI Paper (Muntean et al., 2017) (Collaborative Process)*
*Musqueam PhDGR (Muntean, 2016) (Collaborative Process)*
*DS Paper (Muntean et al., 2016) (System Design)*

*CHI Paper (Muntean et al., 2017) (Study Results)*

This Thesis (Study Results)

**Figure 2.1** Timeline of Previous Work (with Publications)

The following paper describes the first study and resulting design guidelines. It also outlines some limitations of the system as a research artifact.

### 2.1. Paper: Designing Cultural Values into Interaction (CHI 2017)

This paper (Muntean et al., 2016) is located in Appendix A.
2.2. Problems and Limitations of the First Prototype

This initial study showed us that, to some extent, we had successfully embodied Musqueam values within the interactions with the system, as intended (Muntean et al., 2017). However, there were some issues that prevented users from fully experiencing the complex interactions designed into the system. It is likely that these problems limited the results of the first study, limited the potential strength of the contribution, and limited our understanding of the specific mechanisms that might have contributed to our findings in that study; especially those involving embodied cultural values.

The CHI paper (Muntean et al., 2017) identified some specific problems and limitations:

• Nobody who participated in the study was able to access a video by exploring all four categories of information.
• The study demonstrated that the “Teachings” category showed richness & complexity of information, but very few people successfully accomplished it.
• Very few users were able to access as much content/information as hoped.
• Most users did not reach the level of understanding hoped for.
• Regarding the “Understand it” category: users understood what they were supposed to do but were unable to do so.
• “User interface issues”, “interaction design issues”, and “usability” issues. One specific example mentioned was that the ring category often changed due to accidental touches (often without the user noticing).
• That the Belongings system was a complex system with little instruction or feedback; while intending to slow visitors down (which it technically did), it prevented most from uncovering the multiple layers of information available for each category.
• The consent protocol influenced the time spent with the table.

Although these are the only issues identified in the paper, our analysis of the system after the first study (as part of the upgrade process) revealed a more comprehensive list of potential repairs. These are discussed in section 3.2.
It should also be noted that many of these usability issues were not surprising; some had even been flagged as potential issues in the early planning and design stages. However, we decided to minimize help and feedback in the system as much as possible (see section 6.2.4 for further discussion). This was done in order to slow users down to help emphasize both the complexity of information and the Musqueam values that cultural knowledge should be earned and treated with respect. Some technical issues were also known, but due to hardware limitations, combined with a short development timeline, we were unable to solve them in time for the first study.

2.3. Exploring Deeper through New Research Questions

The first study helped us to identify which usability and technical capabilities might be key to experiencing embodied values (Muntean et al., 2017). I sought to address these problems in an updated version of the system, and to iterate on the evaluation of the project through a second study. Rather than repeat the previous study exactly, I decided to attempt to identify more specific mechanisms that might have helped users to experience cultural values. I followed the structure of the original study closely, but modified my research questions (and therefore some of the interview questions), my observation method (to improve detail and consistency), and my consent protocol (to minimize influencing potential participants).

The research question for the first study was:

What are effective design strategies that enable visitors to directly experience cultural values while they interact with Indigenous knowledge using a tangible tabletop system? (Muntean et al., 2017)

This question was useful for discovering general design strategies. In order to focus on discovering more specific design guidelines, I decided to focus on two key components designed into the system: 1. the physical properties of the belongings, and 2. the physical-digital relations in the system. These are core structures for designing embodiment in tangible interaction (A. N. Antle & Wise, 2013), and are where we focused much of our efforts in the original design of The Belongings System. For example, we spent significant effort on replicating ancient Musqueam belongings as accurately as possible (Muntean et al., 2016). We also carefully considered (and debated) how the juxtaposition of different belongings and different modalities might
affect the way users think about Musqueam values, culture, and daily life (Muntean, Hennessy, Antle, Rowley, Wilson, & Matkin, 2015; Muntean, Hennessy, Antle, Rowley, Wilson, Matkin, et al., 2015).

This led me to the following new research questions:

**RQ1** *What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?*

**RQ2** *What are the important physical-digital relations in the system (i.e. control menu, matching activities, unlocking stories) that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?*
Chapter 3.

System Design / UI Revisions

In this chapter, I first briefly explain the form and function of the second iteration of the Belongings System (which is the version used for this study). I then discuss motivations for iterating upon the system after the first study, which changes were made, and why. This chapter includes a pictorial paper made for the Designing Interactive Systems 2016 (DIS ‘16) conference in Brisbane (Muntean et al., 2016). The pictorial visually describes the Belongings System and includes detailed images and explanations of its design, production, and function.

As a side note: in order to give credit where credit is due, I should clarify who did what. This system was designed by two overlapping teams: the design team, and the curatorial team (the members of the curatorial team also belonged to the design team too). I was part of the design team but not the curatorial team. The curatorial team made some design decisions mostly separate from the design team (e.g. which Belongings to use, written copy to include, relationships between belongings). Whenever I say, “we” in the context of a design decision, I am referring to the design team. I try to explicitly reference the curatorial team when a decision was made that did not directly involve the design team.

The Belongings System is an interactive, tangible tabletop exhibit. It consists of replicas of six ancient belongings, six representations of (or actual) modern belongings, two activator rings, three wall-mounted displays (non-touch), an SUR40 tangible tabletop, and a museum cart. Each of the belongings and activator rings has a fiducial marker attached to the bottom, so that the position and orientation can be tracked by the tabletop when they are placed on its surface. The tabletop is running a custom application that tracks touches, belongings, and activator rings, displays and controls activities and information access, and is networked with two of the displays. Each networked display is mapped to one of the rings and only displays content related to that ring. The third display runs a slideshow of Musqueam fishing imagery. The belongings are kept on a museum cart next to the tabletop.
To use the system, a visitor places one of the rings on the table. A circle appears on the table within the ring with the message: “Place a Belonging Here”. The visitor chooses a belonging and places it upon the table. A belonging is only recognized by the tabletop when it is within a physical activator ring on the table’s surface. A digital ring surrounds the physical ring and has four categories on it: “stem te ḥɬ? – what is this?”, “cyeθə̓s – having stories”, “təɬəɬ – understanding it”, and “snəweyəɬ – teachings received since childhood”. The “what is this” category is automatically selected (it is always the default for a new belonging). Beside the ring there is an information card with images and information describing the belonging in the ring; what it’s called, how it’s made, what it is used for, etc. Each information card has multiple “pages” that visitors can manually explore. Selecting a new category brings up a hint card about how to use that category. Understand it and teachings each start a different type of matching activity. Understand it requires the visitor to match their selected belonging with part of the fish cutting scene on the table background by physically moving it to that location. Teachings requires the visitor to match their selected belonging to its ancient/modern counterpart (e.g. ancient counterpart if it is a modern belonging). Successful completion of each of these activities opens an information card about changes/continuity of Musqueam culture, or how that belonging fits within Musqueam life. Once all categories have been attempted, a video is unlocked in the “having stories” category. The visitor can then choose to play that video (which plays on the monitor corresponding to the currently used activator ring). The videos are of stories told by Musqueam elders. There is unique information, stories, and matches associated with each belonging.

This was a brief overview of the belongings system. There is significantly more detail in the conference papers in sections 2.1 and 3.1. The following pictorial shows detailed information about the belongings, imagery used, design and development process, motivations, and interaction. The flowchart on page 11 of the DIS paper is especially helpful for understanding the basic structure of the complex information connected with each belonging.


This paper (Muntean et al., 2016) is located in Appendix B.
3.2. What’s New: UI Revisions

The first study helped us to realise that the research instrument (Belongings System – first iteration) was flawed, and limited us in being able to fully address our research questions. In this section, I give an overview of usability problems and barriers in the original Belongings System identified through the first study and design team analysis. I then present individual UI problems, and the corresponding solutions I developed and implemented in order to attempt to solve those problems, to be able to effectively answer my new research questions.

The first iteration of the belongings system was intentionally designed to have easy and difficult parts. We expected to get a mix of most visitors exploring “what is this?”, some exploring the matching activities, and only a few unlocking the “having stories” videos. We intentionally omitted some hints and feedback from the interface as a technique (Gaver et al., 2003) to filter out those who might not have a “strong enough” desire to uncover new knowledge. However, none of the participants in the first study were able to unlock the videos, even though some of them expressed (in semi-structured interviews) a strong desire to do so. This was not the only indicator of a design flaw/usability problem, but it was our strongest indicator that the system might be flawed as a research instrument. We carefully considered which hints and feedback we could give to users, without laying out a defined path through the system (to maintain open exploration), in order to solve the issues, and minimize the feeling of “broken” features in the interaction. It was also important to decide which of the intentional challenges were actually just barriers to usability (and therefore research instrument flaws), and which were working as intended.

Additionally, there were some fundamental technological barriers that were also causing confusion for visitors. Because they are not a very common technology, tangible tabletops often come with expected glitches. The novelty of the system also can merit some explaining. To mitigate this, many tangible tabletop based exhibits are constantly administered by a docent or guide. However, we did not want a docent present, as we hypothesised that might severely skew our results. We hoped to solve all of these technological barriers and confusion surrounding novelty without hesitation, as they were not intentionally designed into the original system. Fortunately, a tangible tabletop is an excellent medium for automatic hints and instruction; the technology affords it by its very
nature! We only needed to determine how much extra information to hand to users to avoid subverting our main design goals.

3.2.1. UI Problem – How to begin

Users had difficulty understanding how to begin. It is likely that this type of interaction (placing a physical object on a screen) is completely novel to many, and requires some instruction i.e. many users will never even guess that placing an object on the screen will have any outcome at all, let alone being required to do it in a specific order, as in this instance. Originally we placed an info card (Figure 3.1) on 2 sides of the tabletop:

![Image of printed info card](image.png)

**Figure 3.1 Printed Info Card**
Note: this was attached to the frame of the tabletop on 2 sides (original size: 24” x 4.25”)

The challenge with this approach was ensuring that users actually read it. We noticed through anecdotal observations that many users did not even appear to notice the card, and even some of those who did appear to read it proceeded with behaviours that didn’t match those of someone who understood the instructions.

**Solution**

In addition to the printed instructions, we added some text instructions to the interface that appears when a ring is placed on the table surface (Figure 3.2):
Figure 3.2   Ring Hint – Place a Belonging
Note: Version 1 on the left, Version 2 on the right. The outer black ring appears underneath the physical ring (which blocks it), with the black dot in the center. This outer ring helped to improve the object tracking but was not directly visible to the user.

Users still needed to put the ring on the table before getting feedback. However, in addition to the original printed instructions, the rings did not have a “home position” (like the belongings on the cart). This led to them usually being left on the table surface, so we didn’t add any new instructions/feedback regarding the ring.

3.2.2. UI Problem – Matching Activities

Many users didn’t understand how the matching activities worked (Understanding It & Teachings). Instructions were on the printed info card but may have been missed, too complicated/dense, taken out of context, ignored, confusing, etc. I have no specific data to indicate exactly why the written instructions didn’t work, but it was clear that most visitors were not applying the content therein. In the first iteration, when Understanding It was selected, all information cards disappeared and there were no additional hints. When Teachings was selected, a “dock” (a second dot) would slide out from the center to the edge – indicating a ‘connection’ between the two dots. This sliding dot was often interpreted as a suggestion to remove the middle belonging, rather than as a hint to attempt to find a second, matching belonging.

Solution A (Understand It) – Hint Cards + Hotspot Indicators

I added Hint Cards and hotspot indicators. This solution attempted to give the visitors information about what sort of activity to do, without revealing any actual solutions. When a user pressed the Understand it button on the digital ring:
• One of two different hint cards (Figure 3.3) appeared in place of the usual information card. If the pressed the button again, a new hint appeared.

• A dashed outline dividing the image into all of its hotspots appeared for 3 seconds then faded out (Figure 3.4). The color of the outline matched the color of the ring used to activate it (blue or orange).

• Hint cards were slightly smaller than information cards (which was intended to help differentiate between the hint card and a successful match).

![Hint Cards](image1.png)

**Figure 3.3** Hint Cards – Understanding It
Note: these two hint cards alternate with each button press.

![Dashed Outline](image2.png)

**Figure 3.4** Dashed Outline Hint – Understanding It
Image Credit: Reese Muntean. Used with permission.

**Solution B (Teachings) – Hint Cards + Dock Hints + Fade**

I added hint cards, matching-dock hints and a fade animation (instead of a sliding animation). This solution attempted to give the visitor information about what sort of
activity to do (overcoming novelty), without revealing any actual solutions. When a user pressed the Teachings button on the digital ring:

- One of four different hint cards appeared in place of the usual information card (similar to Figure 3.3, but with different copy; two unique hints for ancient belongings, two for modern belongings)
- The matching-dock fades in-position (next to the ring), rather than sliding into position
- The matching-dock has a text hint that depends on which type of belonging (modern/ancient) is currently in the ring (see Figure 3.5)

![Figure 3.5 Matching-Dock Hints – Teachings](image)

Note: If the belonging in the ring is modern, the left image appears. If the belonging in the right in ancient, the right image appears.

### 3.2.3. UI Problem – Recognizing Success

Many users didn’t realize they had correctly completed a matching activity. In version 1, when a match had been made, an info card appeared next to the ring, revealing information about the connection between the belongings. Because users were actively manipulating the system during the match, the card would sometimes quickly appear and disappear as the match was made and then unmade, sometimes the card would appear off-screen and go unnoticed, or appear and quickly change categories due to an accidental touch on the digital ring. Any one of these conditions would typically result in the user continuing to seek a new match, assuming the previous attempt was wrong.

**Solution A (Understand It)**

In order to let visitors know they were succeeding in the activity, I needed to give them better feedback about correct matches. These changes are in addition to the new hint card (see 3.2.2). When visitors made a successful match:
• The info card replaced the hint card. Ideally, I hoped that users would already be aware of the hint card and less likely to miss the info card. Additionally, the instructions on the hint card would probably have convinced visitors to be looking for some kind of a response.

• The matching hotspot in the background image changed from its normal colours to a teməł-toned version (i.e. similar to sepia-toned) (Figure 3.6)

• A dashed outline, the same color as that of the ring being used, appeared around the correct hotspot (Figure 3.6)

![Figure 3.6  teməł-toned Salmon with Outline – Understand It](image)

Image Credit: Reese Muntean. Used with permission.

**Solution B (Teachings)**

In order to let visitors know they were succeeding in the activity, I needed to give them better feedback about correct and incorrect matches. These changes are in addition to the new hint card (see 3.2.2). When visitors made a successful match:

• The info card replaced the hint. Ideally, I hoped that users would already be aware of the hint card and less likely to miss the info card. Additionally the instructions on the hint card would probably have convinced visitors to be looking for some kind of a response.

• The new text on the match dock (see 3.2.2) disappeared.

### 3.2.4. UI Problem – Doing the Right Thing the Wrong Way

Users often didn’t realize that they were doing the right action (attempting to match in the correct way), but had the wrong solution (the wrong match). In other words, they had no way of knowing that what they were attempting to do was correct, even though they were not seeing any results.
**Solution A (Understand It)**

In order to let visitors know they were attempting the correct activity, I needed to give them better feedback about incorrect matches. When visitors made an incorrect match:

- the corresponding hotspot in the background image changed from its normal colors to a greyscale version (Figure 3.7). This works whether the ring + belonging are moving or stationary.
- A hint card (see 3.2.2) with a “try again” style message appeared if the ring stopped moving over an incorrect hotspot. The new messages were:
  -  “Move the ring and belonging to another section of the fish-cutting scene. The connection might not be as obvious as you think!”
  -  “Try another section of the fish cutting table.”
  -  “Keep searching!”
  -  “Good thought, but this isn’t the connection we were looking for. Try again!”

![Greyscale Salmon – Understand It](Image Credit: Reese Muntean. Used with permission.)

**Figure 3.7** Greyscale Salmon – Understand It

**Solution B (Teachings)**

In order to let visitors know they were attempting the correct activity, I needed to give them better feedback about incorrect matches. When visitors made an incorrect match:

- A hint card (see 3.2.2) with a “try again” style message appeared. The new messages were:
  -  “Try a different ancient/modern belonging. The connection might not be as obvious as you think.”
“Try another ancient/modern belonging.”

3.2.5. UI Problem – Understanding & Tracking Progress

Users did not understand the Having Stories mechanism. The progress ring (which was meant to mirror the physical & digital rings) was often perceived as a “loading ring”; users expressed curiosity about what was supposed to load and seemed to think something was broken. Many did not realise that it was indicating progress toward an achievement (a story told by an elder).

Solution

We changed the copy on the card:

Original: These stories share a little about who we are, in the past and in the present. Explore each belonging to unlock it’s story.

Updated: Each belonging can unlock a story about who we are in the past, present, and future. This page helps you to track your progress.

Figure 3.8  Having Stories Reference Card
Note: the “play” button only appears once the progress ring was full.

3.2.6. UI Problem – Poor Touch Response

The system was prone to accidental touches and poor touch response. Occasionally screen touches would be misaligned or missed completely, especially regarding the digital ring. Also, sometimes when users were manipulating the physical ring, their fingers would brush the screen and register unintentional touches – sometimes changing categories without their noticing. This was especially problematic as it compounded on problems 3 and 4; even if a user knew how to do an activity and
was using the correct actions, the system rules would have changed, making it impossible to successfully complete the task without noticing the error.

Solution A: Rebuild

The underlying cause of the poor touch response was that the system running at a slow frame rate. The SUR40 is not a very powerful computer, and our un-optimized software was pushing it to its limits, requiring us to make computational compromises. In order to solve this, we completely re-wrote the system from scratch. It went from running at around 20 frames per second, to several hundred. This allowed us to make more complex calculations including better physics simulations (to check for touch collisions), a new UI library (which came with several years of optimizations), multiple points of simultaneous data filtering, as well as animation smoothing, fading, and other motion smoothing. With this new reduced computational overhead, we were able to filter noise on the touch inputs, only check for touches while the ring was stationary, re-draw and simplify our touch zones, and modify the way the system checked for touch collisions.

Solution B: Side-effect

A convenient side-effect of our optimizations in solution 6.1 allowed us to improve the aesthetics of use of the interface as well. Version 1 of the application felt a little clumsy, twitchy, and/or laggy. Some digital assets would occasionally flicker, be misaligned with or have trouble “keeping up” with their physical counterparts; especially the digital-physical ring pair. The extra computational power allowed us to add some smoothing/filtering algorithms to the rotation and translation coupling between physical to digital assets. At a higher framerate, animations appeared much smoother as well. Although not key to usability of the system, these improvements likely reduced distractions for users, and plausibly, improved their attitudes toward/perception of the system as well.
Chapter 4.

Methodology

In this chapter, I first describe the study design, including comparisons to a previous study and detailed reasons for changing the research questions. I then describe my participant selection criteria and recruiting (including notes on bias). Next I cover the study setting and procedure, followed by a detailed description of my data collection and analysis techniques.

4.1. Study Design

This was an exploratory field study conducted at the Museum of Anthropology (MOA) at the University of British Columbia (UBC), Vancouver, Canada. It consisted of semi-structured interviews of 20 adult visitors. This second Belongings study was an iterative extension of the first Belongings study at the MOA (UBC, Canada) (Muntean et al., 2017). The second study, which forms the basis for my Master’s thesis, was designed, in part, to re-evaluate the Belongings tabletop system after several usability issues had been addressed during system upgrades (see Chapter 3).

The new research questions for this second study are an extension of the original research questions. The research questions were changed in order to:

1. Evaluate the impact of design decisions made during the system upgrades, and

2. Investigate how detailed design decisions and subsequent design features impacted visitors’ experiences relative to our goal for the system.

In the first study, we investigated how a set of general design strategies, which we used during the collaborative design process, impacted visitor experience. In some cases, our results identified specific design features that were effective. However, our research questions were written at the level of design strategies. This shift towards investigating specific design features in our subsequent study is timely, given our positive first study results. Additionally, investigating specific design features is important in order to generate specific design guidelines that designers can apply directly to their work.
In general, design strategies inform design decisions, which are then made concrete in design features. These features provide affordances for, or enable opportunities for, specific visitor interactions, behaviors, thoughts, and feelings. Once it is known that a set of general design strategies is effective in meeting specific design goals, researchers are justified in following-up with a second study to dig deeper. The closer researchers can get to understanding how specific design decisions and features afford the types of behaviors, thoughts, and feelings that relate to a target set of experiential goals, the more specific the resulting design knowledge and guidelines can be.

By investigating specific design features, my new study enabled me to generate more specific design guidelines. I hope that these design guidelines will help designers make decisions about how specific elements of tangible interaction might impact visitors’ experiences of the intangible aspects of cultural heritage (e.g. cultural values).

Our first study provided evidence that some of our strategies were effective. For example, the overall strategy to take replicas of ancient artifacts, place them on a museum cart, and let visitors handle them enticed people to enter the space and interact with the system (Muntean et al., 2017). In this second study, I worked to be a little more specific where possible, and focused on how physical and digital-physical design features supported visitors to experience Musqueam values through their interactions. This shift required changes to the research questions (detailed below) and subsequently, modified interview questions (detailed below). I also changed the recruitment protocol to reduce potential selection bias compared to the original study (e.g. in previous study we approached visitors before they interacted with system, in this study we approached them after so they would not know they were going to be interviewed).

The high-level design goals for the Belongings tabletop system were the same as stated in our first study (see (Muntean et al., 2017) for a detailed explanation of these goals):

1. Draw in people
2. Learn about Musqueam culture
3. Understand richness of Belongings
4. Understand complexity of stories
5. Experience cultural values

The first belongings study was designed around the research question:

“What are effective design strategies that enable visitors to directly experience cultural values while they interact with Indigenous knowledge using a tangible tabletop system?”

This helped us to understand the impact of our high level strategies, and in some cases specific features were identified in the data. However, my new objective was to understand specific design decisions and features that allowed us to meet the above design goals, especially goal #5: Experience cultural values.

I used the Tangible Learning Design Framework to structure my new research questions around specific, design decisions and features (A. N. Antle & Wise, 2013). The framework provides four elements that designers must address in creating a tangible system. It suggests that decisions made by designers for TUIs should concern:

1. Properties of physical objects
2. Properties of digital objects
3. What actions can be taken on physical or digital objects
4. The relations between physical and digital objects.

I developed new research questions using elements 1, 3, and 4. Element 1: Properties of physical objects was of interest because it is about the physical aspects of tangibility. Element 2: Properties of digital objects focuses on digital (only content) and was not included because I was specifically interested in learning about design decisions related to tangibility. Element 3: Actions on physical or digital objects was of interest; not because the interactions I expected visitors to make were not straightforward (they were; e.g. pick up an artifact and place in a ring on the tabletop), but the fact that visitors could pick up and handle objects in a museum context may have actually been out of context for them (see 5.2.2, 6.1.3). Element 4: Relations between physical and digital objects was of interest because it focuses on the relationship between tangible and digital elements. As a result, I created a research question based on each of elements 1 and 4 (my considerations of element 3 could fit into both).

My new research questions were:
RQ1
What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

RQ2
What are the important physical-digital relations in the system that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

In order to address these two research questions, two researchers conducted semi-structured interviews (pre-determined questions, pre-determined prompts, mix of closed and open ended questions) of 20 adult visitors. This study took place during six days (including a one day pilot study) in the MOA gallery space where the Belongings system was on exhibition. Signs notifying visitors of the study were posted at the front desk of the museum and again near the table.

4.2. Participants

4.2.1. Selection Criteria

Interviewees were required to be at least 18 years old because I didn’t have ethics approval for minors. They also had to speak English as their first language (or equivalent) to ensure they could clearly understand the interview questions. This was screened for during the pre-interview questionnaire and was self-reported using the straightforward Interagency Language Roundtable (ILR) English proficiency scale. I sought a balance between male and female and ages. Although I allowed for an “other” gender category, I did not seek a specific balance other than male-female.

Another requirement for participation was for visitors to use the system for at least two minutes. I used this criteria to be consistent with our previous work (Muntean et al., 2017); we had determined that a minimum investment of time was required to explore the system and gain some level of understanding of the concepts we wished to ask them about. This was justified through Block et al.’s analysis of group and individual dynamics at museum tabletops (Block et al., 2015). Following from their work I excluded both intruders, who join an existing group but leave before 2 minutes, and shoppers, who approach an empty table and also leave before 2 minutes.
A final requirement was for visitors to attempt at least one activity beyond “What is this?”. I used this criteria as an additional filter to select visitors who would have some understanding of the system. As my interview questions were about specific aspects of the system beyond what might be immediately visible, I hoped that this criteria would help to avoid speculative answers. After a visitor had spent at least two minutes and tried an activity beyond “What is this?”, a researcher identified them. When they were finished their session (e.g. left the tabletop space), the researcher would approach the visitor and ask them to participate.

In the first study, monitoring the two-minute requirement was roughly estimated, and researchers discerned eligible visitors using their own judgement. In hindsight, this was not consistently applied. Additionally, in the first study, visitors were approached at the beginning of their interaction, whereas in the new study, we approached visitors once they appeared to be finished. With potentially two concurrent people (or groups) actively interacting with the table, it was difficult to keep track of exactly who was doing what. In order to reduce potential issues with selection bias arising from confusion or estimation, I created a structured observation sheet (see Figure 4.3 or Appendix C.). The structured observation data were used as a screening tool in order to ensure that participants were meeting minimum requirements to be interviewed (1. two minute minimum, 2. attempt at least one activity).

### 4.2.2. Recruiting

Researchers discretely observed every visitor who interacted with the table. Once a visitor appeared to be finished interacting with the table (e.g. started to leave the exhibition space), one of the researchers approached him/her, and recited from the protocol script (see Appendix C.): “Hello, my name is _____, (and this is ______). I/we are doing a research study that involves asking people about their experience with this exhibit. May I/we ask you a few questions? It will take 10-20 minutes.” If the visitor agreed to participate, they were taken aside where they filled out a brief demographic questionnaire and were interviewed. If two or more people worked together and there were multiple researchers available, multiple visitors were approached independently for an interview. If only one researcher was available, s/he asked the group if one person
would like to be interviewed on behalf of the group. Some visitors declined to be interviewed, usually citing lack of time. Although visitors were not notified that they would be asked for an interview until they appeared to be leaving the exhibit, signs placed at the entrance desk of the museum and near the exhibit notified visitors that they might be observed and approached for interviews.

We recruited 20 participants; 8 male, 12 female, and 0 otherwise specified, ranging in age from 18-50+. Most visitors (n=15) were from the Greater Vancouver area. Visitors reported a wide variety of professions. 11 participants were students (in varying fields) at the time of the study.

4.2.3. Bias

Occasionally, there were more potential interviewees than researchers, and I had no predetermined criteria for deciding how to select who to interview. Generally the first observed visitor to leave the table was approached for an interview. This technique may have missed visitors who spent significant time (or at least more time than the person who was selected) interacting with the system, and therefore, would potentially have had a better understanding of it. We also only approached people who had already interacted with the exhibit and did not consider, count, or approach those who may have watched another visitor without engaging directly, those who noticed the exhibit but decided not to interact with it, or those who completely bypassed the exhibit. It is also probable that some visitors recognized that they were being observed by the researchers, and may have modified their behavior accordingly.

In terms of researcher bias, this second study was conducted by two researchers, one is a Caucasian, cis male, Canadian; the other is a Caucasian, cis female, American. Both considered finding physical properties of tangibles and/or physical-digital relations in TUIs that might affect visitors understanding of Musqueam culture/values to be positive results.

4.3. Setting

Two researchers conducted the study in the gallery space of the MOA (Figure 4.1) during one week in January, 2016. A third researcher familiar with the project and
methodology covered for one of the two researchers for two days during a family emergency.

Figure 4.1  Belongings System – Exhibit Setup
Image Credit: Reese Muntean. Used with permission.

4.4. Procedure

During the study, researchers observed and timed every visitor of the system, discarding the data for those who used the system for under two minutes. We then approached those who met our selection criteria (see 4.2.1) and appeared to be at least 18 years old as they were leaving the exhibit. We introduced ourselves, verified that the visitor was an adult, and asked if s/he would be interested in participating in a 10-20 minute interview. After s/he completed a consent form and demographic questionnaire, we interviewed the visitor, manually recording responses as well as making an audio recording. Interviews took place in public spaces in the museum near the exhibit (Figure 4.2). We then thanked the visitor, offered to answer any questions, and then returned to observing new visitors. The researchers did not deviate from the pre-determined interview questions and prompts (see Appendix C.).
4.5. Data Collection

I collected data using semi-structured interviews (pre-determined questions, pre-determined prompts, mix of closed and open ended questions. See Appendix C.) conducted after visitors were recruited (after they engaged with the tabletop). I used transcripts of the recorded audio of these interviews to address my research questions as shown the in following alignment chart (Table 1 - Alignment Chart).
Table 1 - Alignment Chart

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Collection</th>
<th>Data Details</th>
<th>Data Type</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Learning (Preliminary)</td>
<td>Semi-Structured Interview</td>
<td>IQs: 1, 2, 3, 4</td>
<td>Typed Words (Transcribed Audio recordings)</td>
<td>2 researchers look for: Common themes, critical themes, interesting/unexpected themes, and limitations in each IQ, then compare for reliability</td>
</tr>
<tr>
<td>RQ1: What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?</td>
<td>Semi-structured Interview</td>
<td>IQs: 5, 6, 7, 15</td>
<td>Typed Words (Transcribed Audio recordings)</td>
<td>2 researchers look for: Common themes, critical themes, interesting/unexpected themes, and limitations in each IQ, then compare for reliability</td>
</tr>
<tr>
<td>RQ2: What are the important physical-digital relations in the system (i.e. control menu, activities (matching x2, unlocking stories)) that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?</td>
<td>Semi-structured Interview</td>
<td>IQs: 8, 9, 10, 11, 12, 13, 14, 15</td>
<td>Typed Words (Transcribed Audio recordings)</td>
<td>2 researchers look for: Common themes, critical themes, interesting/unexpected themes, and limitations in each IQ, then compare for reliability</td>
</tr>
<tr>
<td>Screening tool (&amp; usability tracking)</td>
<td>Structured Observations</td>
<td>Start/end Attempted? Able to Complete? If no, why not?/issues Other obs.</td>
<td>TIME YES/NO Written Words</td>
<td>Real-time verification of requirements before approaching a visitor for an interview</td>
</tr>
</tbody>
</table>

Table 1 - Alignment Chart

4.5.1. Interviews

I used semi-structured interviews to address my research questions (see 2.3). As discussed above, I modified the interview questions from the original study in order to better answer my new research questions. I asked some of the same interview questions for consistency and replication, and added new or modified questions, as needed, to investigate at the level of design decisions and features as per my new research questions. I also wrote optional, specific, pre-determined prompts to clarify or encourage visitor responses.
In order to address both RQ1 & RQ2, I first needed to assess visitors overall learning, and to set the stage for further questions. I did this by starting with some preliminary interview questions asking visitors about what they learned about Musqueam culture and how they learned that, as well as what they learned about Musqueam values and how they learned that (IQs 1, 2, 3, 4) (see Appendix C.). These questions were slightly modified from the first Belongings study to improve clarity.

In this section, whenever I compare interview questions, I state the question from the first study (e.g. “Study 1.IQ1:” is from the first study, Interview Question 1), and then I state the new question directly underneath. “(modified)” means the new question is just a modified version of the first study, usually for clarity. “(NEW)” means a question appeared in the second study that was not in the first study. “(removed)” means a question that appeared in the first study was not used in the second study. I’ve written more detailed explanations for each section below.

Study 1.IQ1: What was something that surprised you about Musqueam culture that you didn’t know before?

Study 2.IQ1 (modified): Can you describe what you learned from the table about Musqueam culture that you didn’t know before?

Study 1.IQ2: What helped you to learn that?

Study 2.IQ2 (modified): What did you read, do, see, or hear to learn this? Optional Prompt: can you be more specific about how you learned that?

Study 1.IQ3: What else did you learn about Musqueam culture?

Study 2.IQ3 (modified): Can you identify and Musqueam values that you learned about from interacting with the table? Optional prompt: what are some things that are important to Musqueam people? What do they believe?

Study 1.IQ4: What helped you to learn that?
Study 2.IQ4 (modified): What did you read, do, see, or hear to learn this? Optional Prompt: can you be more specific about how you learned that?

In order to address RQ1 (about physical properties), I first asked visitors what they thought that the belongings represented (IQ5), then asked about handling the belongings and how the accuracy of those belongings (IQs 6&7) might affect how and what they learned about Musqueam culture/values through them. In the original study, IQ5 and IQ6 were meant to understand the extent to which users understood the concept of ‘Belongings’ i.e. IQ5 used the word ‘objects’ to provoke a comparison between ‘object’ and ‘belongings’. As the evaluation of this concept was more related to a higher-level design strategy, and I wanted to focus on the physicality of the belongings, I changed the following:

Study 1.IQ5: While using the table, you placed different objects in the ring. What do you think those objects represent?

Study 2.IQ5 (modified): What do you think the belongings represent? Optional prompt: Belongings are the objects you placed on the table

Study 1.IQ6: Why do you think we call the objects Belongings?

Study 2.IQ6 (modified): The ancient objects are accurate replicas of actual Musqueam belongings. Did handling accurate replicas affect your understanding of Musqueam culture? If so, what did that teach you about Musqueam culture? Optional prompt: what did using the belongings teach you about Musqueam culture?

Study 2.IQ7 (NEW): Did handling accurate replicas affect your understanding of what values are important in Musqueam culture? If so, what did that teach you about Musqueam values? Optional prompt: what did using the belongings teach you about Musqueam values?

In order to address RQ2 (about physical-digital relations), we asked about using belongings as a form of interaction with the user interface (IQs 8, 9, 10). I first needed to split up another high-level design-strategy question (IQ7; regarding visitors learning information relationships) into questions about specific design decisions about using the physical belongings to interact with digital content.
Study 1.IQ7: The ring helped you to explore 4 categories for each object. Did you notice any relationships between the four categories of information? If so, what relationships did you notice?

Study 2.IQ8 (NEW): Did using replicas to trigger a menu affect your understanding of what information was available about Musqueam culture? Optional Prompt: How So? // Why not? // The 'menu’ is the ring of buttons that appeared on the screen when you placed a belonging on the screen

Study 2.IQ9 (NEW): What, if anything, did that tell you about Musqueam values?

Study 2.IQ10 (NEW): Did you notice any relationships between the four categories of information for each belonging? If so, what relationships did you notice? Optional prompt: How do you think they were related to each other?

I simplified the wording of the questions about using belongings for matching activities (i.e. matching physical belonging to fish-cutting scene, matching physical ancient and modern belongings through a digital interface) to focus on the direct results of visitors’ actions:

Study 1.IQ8: For the 'Understand it’ category, you were supposed to match an object with a hotspot on the background. Why do you think it was important to make that connection?

Study 2.IQ11 (modified): Why do you think you needed to match a belonging to a hotspot on the table?

Study 1.IQ9: 'Teachings’ was similar but was about connecting ancient and modern objects. Why might it be important to match those types of objects?

Study 2.IQ12 (modified): Why do you think you needed to match an ancient and modern belonging?

Study 1.IQ10: a. Were you able to trigger any 'Making Stories’ videos?

b. How did you do it? / Why do you think you couldn’t?

Study 2.IQ13 (modified): Do you know what the Making Stories category does? (Y/N) Why do you think you needed to do the other activities before you could trigger a Making Stories video on the monitor?
I removed 1.IQ11/1.IQ12 and asked about values much earlier as 2.IQ3 (see above), since it was no longer important to wait for visitors to bring up values on their own, as this was one of the higher-level design strategies/goals evaluated in the first study.

Study 1.IQ11 (removed): Can you describe what you learned about Musqueam values that you didn’t know before?

Study 1.IQ12 (removed): What helped you to learn that?

I concluded with the same open ended questions as the first Belongings study, which were about actions on the table and manipulating the belongings, in order to gather final thoughts from visitors after being asked about physical-digital relations:

Study 2.IQ14 (unchanged): A central Musqueam value is that cultural knowledge should be treated with respect. Can you describe any ways you might have experienced this value by what you did? Optional prompt: Were there any specific actions that helped you experience respect for cultural knowledge? // ...not something you read.

Study 2. IQ15 (unchanged): How do you think other values might have been reflected in what you did with belongings on the table? Optional prompt: You may have learned values by reading or seeing pictures, but what values were portrayed through actions using the physical objects (belongings/artifacts)?

I hope that changing these questions incrementally after identifying research instrument limitations improved my construct validity.

4.5.2. Structured Observation

We used a structured observational sheet during screening to record start time, and determine if the visitor had attempted one activity in addition to “What is this?” (Figure 4.3). I also wanted some observational data to help me identify usability issues that might limit visitors from progressing through the content of the system (as they did during the first study). Observations took place before approaching each visitor. Researchers recorded the start and end times (start time began when a visitor placed a belonging in the ring, and ended when they walked away). They recorded whether each visitor attempted (A*) the task associated with each of the three categories (Understand It, Teachings, Having Stories). They recorded whether each visitor completed (Y, N) the task, and any observed reason or issue(s) preventing them from being able to complete the task, if applicable (“If no, why not? / issues?”). General usability issues and/or any
other unstructured observations were recorded under “(Other notes)”. Once a visitor crossed the two minute threshold, they were assigned an incremental UID (User Identification) number.

<table>
<thead>
<tr>
<th>Able to</th>
<th>Y</th>
<th>N</th>
<th>If no, why not? / issues?</th>
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<td>Start Time:</td>
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<td>Understand It?</td>
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<td>Teachings?</td>
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<td>Having stories?</td>
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<td>(Other notes):</td>
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<td>End time:</td>
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</tbody>
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Figure 4.3  Structured Observation Recording
Note: this is the structure for each potential user. See Appendix C. for the full sheet

4.6. Data Analysis

Interviews were recorded (audio only) and later transcribed by a professional third party. To analyse the interview data, we used a similar thematic analysis process to the previous study that was found to be reliable (Creswell, 2013; Muntean et al., 2017). In this case, two researchers instead of three performed the analysis.

Each researcher looked at the data for each interview separately. We individually analyzed the transcriptions using an open coding scheme to identify themes. Each researcher went through two passes. In the first pass, we identified themes, looking especially for those that related to either physical properties of belongings and how they affected visitors understanding/experience of Musqueam culture/values (RQ1) or physical-digital relationships in the system and how they affected visitors understanding/experience of Musqueam culture/values (RQ2). We categorized the themes as common, interesting, critical, or unexpected/limitation. In the second pass we compared across data sources (between interviews) to fine-tune our themes, looked for missed or redundant themes. Then the two researchers met together to compare. This process was nearly identical to that of the previous study [cite CHI paper]. We did not compare our new themes with the themes from the previous study as part of the analysis. Additionally, the primary investigator later did a second and third pass of
random subsamples of the interview data several weeks apart in order to verify and clarify the findings. No new themes were identified in these subsequent passes.

The researchers agreed on nearly all themes. We found that we used different wording for the same theme on multiple occasions. Upon discussion, we decided to do two merges: three similar themes into one, and two similar themes into one.
Chapter 5.

Results

5.1. Analysis Summary

We used an open coding scheme looking for common, critical, interesting/unexpected themes, and limitations. Based on the data found, we devised ten themes; five for each research question. Two researchers coded independently and agreed on nearly all themes. We found that we used different wording for the same theme on multiple occasions. Upon discussion, we decided to do two merges: three similar themes into one, and two similar themes into one.

5.2. RQ1

What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

5.2.1. Accuracy + detail of [ancient] belongings

This theme is about the physical material properties of an object and how that impacted the users’ expressed understanding of the efforts/reasons/motivations of the (real) people who made them. We found that an important physical property of the belongings was our decision to make the replicas that we used as tangible interface components as accurate representations, including precision (e.g. size, texture, weight, colour), detail (e.g. damage), and authenticity (i.e. replicated, not a novel creation). Users expressed that this accuracy caused them to consider the amount of work, skill, time, knowledge, and dedication that was required to make the original object:

They’re shaped really beautiful and somebody’s taken the time to do that and there’s no rough spot... I know also Musqueam are hardworking people, so there’s -- there’s, you know, all these older pieces -- I mean, some of them are fragmented, but they were all finished. Like, they weren’t half-assed, right? Kind of, if you’re going to do something, do it well.” (FF05, IQ7).
Users tended to speak about how the original, ancient belonging was produced, rather than how the replica was produced:

(referring to another exhibit with 3D printed replicas) [P]otentially you could become really interested in the technology of 3D printing, which is really interesting, and direct your attention to that and less maybe about what that object is…” (EE03, IQ6).

Users also said that accuracy helped them to consider the material of the original belonging (as compared to the material of the replica), which helped them to understand how the belongings were made, and/or how long they might take to construct:

Well, I guess you could imagine like when you’re looking at the net weights that all these things are natural resources and they obviously are not industrially produced, you know. This is — and every different person would probably present those objects differently, like I’m sure everyone had different techniques and it’s really interesting because they would take forever to make.” (CC01, IQ7).

This theme was also found in the first study as part of the broader design recommendation, “Cultural Forms”, which suggests designers use both physical forms and social practices around them to reflect values. This theme is more specifically about accurately representing those physical forms.

5.2.2. Presentation/Context of Belongings

This theme is about the social practices surrounding the way that ancient objects are physically presented in a modern context, and how that impacted the way that users expressed that they perceive, approach, and handle said objects. We decided to place the belongings on a museum cart as if they were actual specimens from the museum collection (i.e. on a stainless steel cart, with each belonging placed upon the clear zip-top baggies that the museum uses for specimen storage; the cart placed haphazardly near the table, as if a museum worker had left it there) (see Chapter 3). We heard from users that finding Belongings presented this way caused them to treat the belongings with care and respect, because they believed (or suspended their disbelief) that they were real, or because that is what the contextual social protocol would suggest:

Prior to knowing that they were replicas, I was handling them with a bit more respect and not just lobbing them back when I was done with them and sort of placing them down. (EE02, IQ14)
There’s that you learn well from feeling tangible things and a lot of Musqueam collections you can’t touch because they’re behind glass, so learning about size, weight, and feel -- can maybe feel more personal and relatable. (CC02)

This theme was also found in the first study as part of the broader design recommendation, “Contextualize”, which suggests that designers provide context through different modalities. This theme is more specifically about the social practices surrounding modern modalities.

5.2.3. Physical Contact/Handling

This theme is about being allowed to touch and handle accurate replicas and how that impacted the users’ expressed feelings of connection, and understanding of the concrete reality of Musqueam culture. We decided to allow users to easily handle all of the replicas. The design and curatorial teams worked together to afford this by: choosing belongings that were small enough for little hands, making the replicas robust/durable, and not anchoring the replicas or designing other physical constraints as to how they might be used or handled (which required us to trust users not to take them). Users said that being allowed to hold and touch objects that they perceived/interpreted (again, suspension of disbelief) as being real belongings, made the ancient Musqueam culture, people, and their values seem more real, genuine, and valid (a/b/e)

I think being heard and seen is something that gives culture and people great value, right? (FF01, IQ14)

It was just a much more genuine interaction...[handling accurate replicas] enhanced the experience and made it easy to connect with what values were being communicated to a certain item. (BB03, IQ6&7)

Users expressed feelings of connection in handling objects; they said they could imagine making and/or using these every objects, tools, etc.:

I assumed they were kind of more or less the real thing...being able to handle anything that other people have made is kind of -- I don’t know. It’s an idea of connection to the person has made it. (EE04, IQ6&7)

We also found that having to handle and manipulate objects takes time and slows interaction. Users said this increased the depth of their consideration of those belongings:
Really just the time that it takes to manipulate them to get an understanding of them, and they have a lot of depth and they have a lot of -- they carry a lot of stories and connections...that things were made by hand, that things took time, that there's skill involved, that there's knowledge. (FF03, IQ14&6)

One user discussed how handling objects while reading on-screen text improved their level of engagement with, and understanding of the written copy within the system. S/he stated,

it makes [the written copy] more meaningful to me... it has an impact on me. (BB01, IQ7)

This theme was also found in the first study as part of the broader design recommendation, “Hands on values”, which suggests that designers design the physical properties of tangibles to immediately portray values though sight and handling. This theme is more specifically about visitors being allowed to handle objects that could be perceived as real, through the physical property of accuracy.

5.2.4. Everyday Objects [as Belongings]

Users told us that handling ‘unexceptional’, everyday objects created connections to the people who created and used said objects. Often, in museums, visitors only see the most extraordinary, interesting, and beautiful pieces on display, but they are not a typical representation of the everyday objects that belong to, and were used by, ancient peoples. Museums might have thousands of ‘everyday objects’ in storage that are never seen by the general public. The curatorial team decided to select belongings that were not the typical, ‘beautiful’, exceptional objects that might ordinarily be displayed in a museum, but to select samples that they felt represented a cross section of the hundreds or thousands of unseen, day-to-day belongings to use as the tangible interface elements. We then designed our TUI system around these objects, using replicas of them as the tangible elements of the interface (see theme RQ2 – 5).

User’s expressed connections with the level of craftsmanship that would have been required to build functional objects:

I think touching [the net weight] and seeing how it’s carved out stone and like the level of craftsmanship that has to go into something like that especially something that gets used so much...it’s very different having something like that in your hands. (CC01, IQ6)
Users expressed connections to aspects of the culture and way of life of Musqueam people related to functional objects:

[The belongings represent] things that are, like, that represent different aspects of culture and way of life. Because I suppose there was different aspects in terms of like trade and economy and then also like fishing, eating, or (inaudible). (DD01, IQ5)

Users also said that they were able to relate to ancient peoples through what they:

[might be] carrying around in their pockets the way people today would be carrying, you know, car keys or money. You know, I guess, Musqueam people today and maybe in the past might be walking around with a couple of pieces of [fish hook] in their pocket or something equivalent to that. I like that. It makes it real. (BB01, IQ6)

This is a new finding, as compared to the first study.

5.2.5. Contrast of Ancient and Modern

This theme is about using both ancient and modern belongings and how users said that it affected how they connected Musqueam culture to things they already know. We found that the decision to include accurate replicas of ancient belongings alongside accurate replicas (or actual samples) of modern belongings in the same context was important for relating ancient culture to modern life. Five examples of the design and curatorial teams’ considerations about context include:

1. our decision to place them next to each other on the museum cart,

2. how ancient belongings might relate to a modern belongings in surprising, unexpected, and/or interesting ways,

3. how all belongings might relate to the ancient and modern Musqueam way of life,

4. the designed physical-physical matching activities,

5. the designed physical-digital matching activities,

We also found that the curatorial decision to choose ancient-modern pairs with considerations for how they relate to each other roused curiosity. Three examples of the considerations of ways belongings might relate to each other include:
1. Ancient-modern equivalents (e.g. modern axe to ancient adze used for carving),

2. Unexpected/ambiguous modern-ancient relationships (e.g. ancient adze to modern Coke can to tell the story of historic and contemporary trade routes),

3. More marked modern-ancient relationships (e.g. Coke can to salmon fillets to frame information about the impact of contemporary issues on traditional diet).

The curatorial team framed the selection of all of the belongings around fishing (an important element of Musqueam culture) to limit the scope, which also helped us to tell a cohesive story. Users expressed that the contrast between ancient and modern helped them to create a connection to the past and to understand the continuity of Musqueam culture:

You know, people fish traditionally, but then they still fish today and it’s the same activity... And the technology is different, but it’s still fishing, right? (EE03, IQ5)

I think to make the connection between the -- the Musqueam culture now and the past. And I think not being Musqueam you tend to think of it as in the past, but it’s living now. And then how that is separate from these other parts of life...? (DD02, IQ12)

...it just links up people’s knowledge and understanding and it makes a lot of sense, and, you know, triggers a deeper understanding by having those connections. Like, you’re just thinking about something that’s probably in your day-to-day life differently and how the idea that you have of that can conceptualize a different worldview. (CC01, IQ12)

Users also told us how ancient-modern pairs roused their curiosity through a combination of familiar vs unfamiliar as well as through confusion, ambiguity, and/or surprise (i.e. “how does this fit?”).

I don’t understand at all how this fits with traditional culture... [and later realized] it wasn’t so much that it fit in with the way in which trade traditionally happen, but that it represents that sort of significant shift in the way in which results had be used where they go. (DD01, IQ1&IQ2)

This theme was also found in the first study as part of the broader design recommendation, “Connect”, which suggests that designers connect the exhibit to the visitors’ lives. This theme is more specifically about contrasting ancient and modern aspects of the lives of the exhibit subject (Musqueam people), rather than directly to the visitors’ lives.
5.3. **RQ2**

*What are the important physical-digital relations in the system that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?*

### 5.3.1. Multiple Pathways

This theme is about having several pathways for users to navigate digital content using tangibles (belongings), and how that impacted users’ expressed understanding of the value of Musqueam culture. We decided to design a ‘web’ of options for users to interact with the system; i.e. users could a little or a lot of information through several forking and bidirectional paths. Users would select any one of six ancient or six modern belongings, and then could complete up to four activities with each one. Some information could be revealed by more than one different belonging via ancient-modern matching activities. However, users were not given any indication of a correct order or even a minimum amount of work in order to “succeed”; they were free to explore the information in any order. Users talked about how the perceived complexity of the system actually demonstrated the value of objects, stories, and knowledge:

...you kind of have to flush out what I had been learning...I know it wasn’t a contest, but I almost failed. They were telling you, well, we want you to understand this better before you access our storytellers and knowledge keepers. (FF06, IQ13)

...each piece, no matter how small or trivial it looks, is extremely valuable...It’s extremely valuable and they have meaning, that it has a story, that it has all of those things. (FF02, IQ8&9)

Users also said that multiple pathways (without mentioning any specific pathway) gave a sense of the abundance of information about Musqueam culture:

It made me realize how much information there actually is and, like, how, like, there’s a lot of teachings and people know a lot and it’s not like this lost, you know, culture. (FF07, IQ8)

One user told us how this helped him/her to foster empathy:

...that process of exploring, where could this fit here and try to – almost like put yourself in the shoes of people who were using that type of technology, and trying to make the link between what you’re seeing and where that would fit in, you know? (EE01, IQ2)
This theme was also found in the first study as the design recommendation, “Non-linear explorations”, which suggests that designers allow for multiple different pathways for exploring information. This theme is effectively a confirmation of that design recommendation with a slightly different framing (see 6.2.2).

5.3.2. Challenging Visitors

This theme is about requiring users to earn some information through sometimes difficult activities, often by mixing logical connections with ambiguous relationships in matching activities, and how users expressed that this impacted their understanding of the value of information about Musqueam culture. We found that the decision to make the solutions to some activities difficult/challenging – enough so that many users would not be able to complete them all without investing some time and effort – was important for helping users to understand specific Musqueam values, especially the value that access to cultural knowledge should be earned. Users told us they felt they needed to work hard to gain deeper understandings:

I feel like I had to work pretty hard to like figure out what it was. And like put it on the table and like it was very thoughtful. It was a thought process. (FF07, IQ14)

It kind of forces you to put in some time and effort [to] engage with the information instead of just sort of standing there and seeing what you want and whatnot without relationships; relationships to the objects; relationships to the people. (FF05, IQ15)

…it's not easy and I saw a lot of people that would come by and kind of, like, not follow through with a lot of it. But you if you want to know, then you're going to, like, put the work in, obviously, and keep, like, going at it because it doesn't all kind of [inaudible] itself all at once, obviously. (CC01, IQ14)

They said that they felt like they might be missing out on some valuable knowledge:

I think it was like a missing piece in the puzzle. There was something that I did not know yet that I couldn't find out. It was kind of irritating me because I didn't achieve that goal. I was kind of missing -- always missing the full picture of that history. So it was quite a mystery until I found that correct piece. (BB04, IQ11)

And how new knowledge felt earned:
...it doesn't give it to you all at once. You kind of have to work for it. And if you're going to ask me about Musqueam values again, that kind of makes sense. Just like in the story that gets told about the smoked salmon, and, like, you have to go through and kind of struggle with the knowledge yourself first, and, like, kind of reconcile it in your mind and make connections first. And then you get a story about it that kind of brings it all together. And then you get to actually hear, like, a live person speaking, and that's a privilege. (CC01, IQ13)

Users also expressed that success required patience and dedication:

Well, I think that there’s the patience required to actually unlock the meaning and the stories and the teachings. (FF03, IQ15)

...it's not easy and I saw a lot of people that would come by and kind of, like, not follow through with a lot of it. But you if you want to know, then you're going to, like, put the work in, obviously, and keep, like, going at it because it doesn't all kind of [inaudible] itself all at once, obviously. (CC01, IQ14)

But that this effort felt analogous to respect/value of knowledge:

...it demonstrates a certain kind of understanding. Not -- competency is not the right word, but, like, levels of understanding that you're able to get before you can, kind of, fully appreciate the significance of something. (DD01, IQ14)

[the exhibit] forces the [user] to take the time to explore each [belonging] and think about things before -- contemplating it; before moving on to the next thing and trying to guess the end of the story and look at the last page. (BB02, IQ15)

This is a new finding, as compared to the first study.

5.3.3. Incremental Layers

This theme is about users being given incremental layers (in small snippets) of information with each activity (for each belonging), and how users expressed that this helped them to gain a deeper understanding of Musqueam culture, than they might have gained with a single dimensional presentation of information. Users also expressed that deeper, incremental information helped them to take responsibility for their own learning, and to relate new knowledge to the tangible belongings. We decided to initially give users a small amount of basic, yet interesting information (“what is this”), but required them to complete some activities using the tangible belongings in order to gain access to additional information about that belonging. Each activity immediately displayed new
information and further information could be accessed by scrolling through multiple, now-unlocked, pages. “Having stories”, which is the most guarded information, required all activities for a given belonging to be successfully attempted to unlock it. Users said that earning information incrementally helped them to build a foundation for new knowledge:

we want you to understand this better before you access our storytellers and knowledge keepers. (FF06, IQ13)

It also helped them to gain multiple levels of understanding:

[The exhibit] forces [users] to take the time to explore each [belonging] and think about things before -- contemplating it; before moving on to the next thing and trying to guess the end of the story and look at the last page. (BB02, IQ15)

Users also said that incrementally earning information helped them to create deeper meaning through big-picture understanding ([regarding activities before story]):

...because you have to know what it's used for. You need to make some connection to it as a learner and then the story, I think, should come last...like you need to know the vocabulary first before you can read a story, so you need to know stuff first and then you have a better understanding of -- of The Story.(FF02, IQ13)

Users expressed that incremental information helped them to understand that it was up to them to decide how much to learn:

I think the pace at which you interacted with it. The fact that you had to match things up, the fact that you had to interact with a few objects before the narrative becomes available; that gave the viewer or the audience a chance for contemplative pause to think about each object before just rushing in and looking at the shiniest, brightest, or whatever -- most eye-catching one. (BB02, IQ14)

They also expressed that incremental information ultimately helped them to map meaning/knowledge back onto the tangible belonging:

Well, just the depth of information that came out of each object, just in the slide, and then it’s reinforced with the stories from the storytellers. Yeah. Really just the time that it takes to manipulate them to get an understanding of them, and they have a lot of depth and the have a lot of -- they carry a lot of stories and connections. (FF03, IQ14)

This theme was also found in the first study as part of the broader design recommendation, “Accessible Information”, which suggests that designers create opportunities for immediate interaction and access to basic information. That design
recommendation touches on the incremental/deep ideas of this theme, but mentions that most users in that study did not reach that point. This is likely due to usability issues discussed earlier as those ideas are demonstrated here.

5.3.4. Quick Access

This theme is about users being given direct and immediate information connected to each belonging (through ‘What Is This’) and how that helped users to gain additional insight as compared to images or touchscreens alone, or objects behind glass. We decided that (essentially) no information would be given to users initially, but that by placing an item in a ring on the screen, information about that item would be immediately displayed next to it through the category “What is this?”. The information we included here was directly about that specific belonging, for example: how it was/is used and by whom, what it’s called in English and हौंहेमिनह, how it is/was made, etc. Much of what was included here would be similar to typical, non-interactive, museum exhibit writings; for example, what a museum visitor might see written on a placard next to an item behind glass. However, this info was accessed by the user through actions executed using a tangible replica of the belonging which the newly displayed information refers to. Users said that the information given immediately upon placing a belonging in the ring created an immediate connection between specific knowledge and the belonging:

I think it gives a bit more insight into what it actually felt like as opposed to looking at pictures of them. You don’t really get the tactile feeling of being able to hold a piece of culture... Just easier to sort of understand and having the little touch menus and being able to access the cultural information like that. (EE02, IQ6&8)

I could have imagined that table being completely blank and you just put a ring down and an object inside. I didn’t really make much use of the photo of the knife or the dead fish or anything that was on there. I mostly was just reading the things that were coming out of the wheel. (EE04, IQ8)

This theme was also found in the first study as part of the broader design recommendation, “Accessible Information”, which suggests that designers create opportunities for immediate interaction and access to basic information. This theme is more specifically about using that easily accessible information to establish a solid connection between the tangible belonging and the object it represented in order to be
“apprehendable” and to quickly engage “walk up and play” users (A. N. Antle, Tanenbaum, Bevans, Seaborn, & Wang, 2011).

5.3.5. Belonging (artifact) as Tangible Interface

This theme is about using accurate replicas of Musqueam belongings as tangible interface elements and how users expressed the ways this helped them to understand the larger story connected to each belonging. We decided to use extremely accurate replicas of actual Musqueam belongings as the primary tangible elements of the interactive system. The curatorial team selected which belongings would be used before creating the content of the system; writing the content (including 'what is this' information, matching activities, and inter-object relationships/stories) based on the chosen objects. Because of these design decisions, users are effectively handling the object about which they are being taught. Although using a physical object to literally represent corresponding digital information (vs. a metaphorical relationship between physical and digital) is a common practise in TUIs, a critical decision here is that our tangible elements were copies of actual belongings (objects that belong to people who lived or are still alive), and were produced to be as similar to their real counterparts as possible. Users said that they learned new things by connecting expanded information on the table to the belonging:

...I think, maybe, the Musqueam belongings were more clearly symbolic, and they told a story. In the case of the other, the modern objects, I think some of the links for me were clearer than others. In many cases, it was through the reading that I could really get, “oh, this is how – why the ice cube connects to... (FF06, IQ5)

It made me realize how much information there actually is and, like, how, like, there’s a lot of teachings and people know a lot and it’s not like this lost, you know, culture. (FF07, IQ8)

They also expressed that multimodal information connected to the belongings told a larger story:

[I learned from a] nice combination of having the objects and getting from the table, well, the meanings and what they were used for. And I liked how it combined the quotes, kind of like extract from conversations with the other type of data. Yeah. I think it was a combination of different kind of like, types of information—what made if more—yeah. Kind of like a feeling or (inaudible). (FF06, IQ4)
It’s kind of like the different types of bringing the information to you; so having the object and making you like go to the table and like giving you some quotes and some history and then the video. (FF06, IQ5)

And that belongings can be connected to memories:

...remembering through objects, through belongings, the importance of or maybe sometimes the only way to remember things. (CC02, IQ7)

This theme was also found in the first study as parts of the broader design recommendations, “Cultural Forms”, which suggests that designers use physical forms and social practices to reflect values, and “Hands on values”, which suggests that designers design the physical properties of tangibles to immediately portray values through sight and handling. This theme combines elements of both (an actual cultural form, its modern and ancient contexts, extreme accuracy), while additionally suggesting that all parts of the system relate back to a single, real object (while it is being used as the interface), rather jumping focus, or relating back to something invented.

5.4. Interesting

This section is a collection of other visitor quotes that the reader might find interesting. Some do not fit into other themes, but don’t have enough supporting evidence to merit a new theme. Some may fit into multiple themes and are useful as supporting evidence.

I think there’s a lot of material here that asks one to read, which is very passive, and that’s okay, but, you know, I can only do so much of that. And so being able to handle the objects it engages me more, and so I’m going to pay more attention to what I’m reading if I’m holding the object. It’s much more active for me and I retain the information better than just reading about it. (BB01)

I think it's not fair for whoever put together this exhibition for them not to put accurate replicas of everything because then it wouldn't be representing them the right way and their culture and their values, and they -- they deserve that. (DD03)

the technology is different, but it's still fishing, right? (EE03)

[With pictures] you don't really get the tactile feeling of being able to hold a piece of culture. (EE02)
[Handling replicas brought] a real connection [back to the idea] that things were made by hand, that things took time, that there's skill involved, that there's knowledge. (FF03)

...take the time to explore each [belonging] and think about things before contemplating it; before moving on to the next thing and trying to guess the end of the story and look at the last page. (BB02)

...it doesn't give it to you all at once. You kind of have to work for it. And if you're going to ask me about Musqueam values again, that kind of makes sense. Just like in the story that gets told about the smoked salmon, and, like, you have to go through and kind of struggle with the knowledge yourself first, and, like, kind of reconcile it in your mind and make connections first. And then you get a story about it that kind of brings it all together. And then you get to actually hear, like, a live person speaking, and that's a privilege. (CC01)

...it demonstrates a certain kind of understanding. Not -- competency is not the right word, but, like, levels of understanding that you're able to get before you can, kind of, fully appreciate the significance of something. (DD01)

And I think that hands-on learning, especially for youth, especially would be super valuable because that’s how you picture holding that cutting tool in your hand and picturing and seeing the fish open really adds to your understanding of what -- that that was used to actually cut. And people did have that. So, you know, it was like making tools for daily stuff. (EE01)

It’s really easy for us to disregard stories sometimes, I think. There’s that -- just that attitude of get over it, because we’re not willing to see what lead to that point and what is important and what isn’t to the people. So seeing it all connect I think hopefully makes people realize that like there is a reason for everything and there is real people that this is affecting and they’re not just, you know, making things up in their head for why this is important. (FF01)

I think just getting to touch the ancient artifacts and -- or the replicas and seeing the stories just -- it gives it value. I think being heard and seen is something that gives culture and people great value, right? Like the best way to hide history is to erase it. So if you can make it seen, then it shows how important it is, you know? (FF01)

Using the table that way, you're engaging with it. You're doing some work. You're looking... you know your questions and then you have to kind of work for it...it kind of forces you to put in some time and effort [to] engage with the information instead of just sort of standing there and seeing what you want and whatnot without relationships; relationships to the objects; relationships to the people. (FF05)

I'm not sure if I get a value from [the links between the four categories] -- like a particular value, but I do get a sense of what they wanted visitors to know about that, and they story they wanted to tell. (FF06)
We want you to understand this better before you access our storytellers and knowledge keepers. (FF06)

5.5. Limitations

5.5.1. Limitations of the Belongings System

This section is a very brief overview of some of the outstanding challenges and limitations with the belongings system, including usability issues. It is both for the benefit of the reader to help determine the validity of the system as a research instrument, as well as an indicator of further work for any future iterations. They are in no particular order.

• Progress bar still problematic (at least 1 user saw it as a stuck loading wheel, another user didn’t understand the connection to progress) (EE03)

• Trial & error/guessing was considered by at least 1 user, that it “may not be respectful” (DD01)

• Trial & Error/guessing were sometimes frustrating

• There are still some programming and hardware bugs and glitches (table occasionally has trouble recognizing an object, progress reset when shouldn’t in at least 1 instance, tracking was occasionally intermittent)

• The novelty of the technology can be distracting (it can overwhelm potential meaning and/or relationship with the interaction and content)

• At least one user thought the table was possibly too small (this could also just be a UX/UI design problem)

• The ring was sometimes confusing to use (unclear if this is this a technology/interface limitation or an understanding/informational problem)

• At least one user was confused by the use of heñqəmər̓nəm̓ language on the ring

• At least one user mentioned it was “too interactive” (BB02). In other words, it could be especially confusing to non-digital natives i.e. could your grandma use it?

• Difficult or impossible to learn anything from the system if you don’t want to interact, i.e. you can’t just read about the belongings, you have to take some action. This is probably not actually a limitation considering our design strategies, but was mentioned as such by a user

• At least one user didn’t understand that each monitor mapped to a distinct ring
• At least one user still thought the fish-cutting monitor was an unlocked Making Stories video (BB03)

• At least one user unlocked the video, but didn’t know it (DD02). Anecdotally, it appears as though that happened several times

• At least one user didn’t see the navigation arrows, and therefore didn’t notice that there were multiple cards to scroll through at a given time. This is also a basic UX & UI design problem, however, we used commonly practiced web UI techniques for this feature. It is likely that some users with lower digital literacy will always struggle with a digital UI, no matter how complex. It is still a limitation but it is in a category that is difficult to solve, and may have diminishing returns. Discussion point: at what point should we compromise advanced, experimental features for accessibility and traditional usability (i.e. User-Centered Design practices) in real-world and/or long term installations and exhibits, if ever?

5.5.2. Limitations of Study Design

In this section I discuss some limitations of the study design.

The results in sections 5.2, 5.3, and 5.4 are based exclusively on an analysis of semi-structured interview transcripts using an open-coding scheme, which is subjective. I also collected structured observations for the sake of identifying usability issues for a potential future iteration, but these were not useful for data analysis. The interview questions were pre-determined, and interviewers were instructed to adhere strictly to the prompts. The questions were a mix of open- and close-ended and were all written by the author. What a participant tells an interviewer can’t be 100% trusted as fact, and so it can be difficult to make completely confident claims from such techniques. There is also the possibility of bias in both the writing of the interview questions and the analysis. See chapter section 4.6 for details on how I attempted to mitigate this.

The sample size of n=20 is on the low side for an exploratory field study. We were planning to interview 25 to 30+ people but extenuating circumstances made that impossible. We also only interviewed adults (18+ years old) as a provision of our ethics approval.

This study took place entirely in a single location and the table was part of a larger exhibit covering some of the same themes. We had no procedure in place to attempt to understand any potential relationship or impact connected with the surrounding exhibits.
I only interviewed visitors who had engaged with the exhibit and were willing to be interviewed. Visitors who were shy or rushed may have been less likely to participate but may have responded in different ways to those who did participate. Although the interviewers tried to be inconspicuous, it is possible that some visitors may have altered their behaviour because they thought someone was watching, or because they expected to be asked about their experience. We also posted privacy notices that may have influence visitor behaviour. It is also possible for there to have been bias in participant selection. See chapter section 4.2 for details on how I attempted to mitigate this.

One uniquely important limitation of this study is that it was not evaluated with any members of the Musqueam community for complex reasons. It would be very interesting to see how Musqueam nation members might respond to a system that is attempting to portray values that they (presumably) already hold.

Finally, there is novelty effect. It is very likely that the majority of participants have never encountered a tangible tabletop system (in fact, we presumed this as part of our design processes and tried to consider it in designing most aspects of the system). It is possible that this could swing our results overly positive or negative. In other words, people may respond differently to this system once they become accustomed to it, than they do when it is novel to them.
Chapter 6.

Discussion

In this chapter, I discuss the implications of the results presented in chapter 5. First I identify and elaborate on four findings that were more specific extensions of findings from our previous study (Muntean et al., 2017), but are unique within the larger body of work. Then I discuss other findings and frame them within the existing body of work. Finally I present the implications for design based on the results and findings, discuss limitations of the study, and offer ideas for future work.

6.1. Preliminary Findings

The interview results revealed some findings that were more specific subsets of those of the first study (Muntean et al., 2017), and are discussed in detail below. The findings that contribute preliminary new knowledge to the design space of tangible interaction design for embodied cultural values are:

1. The design strategy of using everyday objects rather than extraordinary artifacts to create tangible objects helped visitors to relate to the culture they were learning about.

2. The design strategy of using faithful reproductions of artifacts, rather than coarse or metaphorical approximations, to create tangible objects encouraged visitors to consider the history of real artifacts that belong(ed) to real people.

3. The design strategy of breaking existing social practices between visitors and artifacts in museums fostered curiosity and respect from visitors.

4. The design strategy of using replicas of both modern and ancient cultural artifacts to create tangible objects helped users to connect with the culture they were learning about, and to understand the continuity of that culture from the ancient past through to the present.

6.1.1. Everyday Objects

Interview results indicated that using and handling replicas of everyday, functional, cultural belongings, rather than replicas of extraordinary cultural artifacts,
helped visitors to connect and relate to the Musqueam way of life. Using everyday objects as tangible interface elements helped visitors to gain insight into how the people they are learning about actually lived. One visitor suggested it was equivalent to seeing what we carry around in our pockets. Exceptional artifacts typically belong to the most important or wealthy people, or they may be associated with rare moments, rituals, or exceptional circumstances. Museums often showcase these sorts of artifacts, as they can be more interesting to see behind glass (not to mention they can be exceptionally beautiful). However, they may not be as useful for demonstrating some portions of ancient and living cultures as everyday belongings.

Through handling everyday objects, visitors related to the way of life of ancient and modern Musqueam people. Visitors gained insight into what was important to them in a very real way. Visitors understood that everyday belongings are/were important to Musqueam people in part because they require knowledge and effort to create, and because they afford a specific way of life. The objects used indicated to visitors the value of fishing and trade in their ancient and modern day-to-day lives. Visitors also gleaned that high-quality craftsmanship is/was important, even in objects that we might perceive as purely functional, even with materials that are difficult to work with. They also related craftsmanship with the value of history and being taught by experts (see sections 5.2.1, 5.2.3, 5.2.4).

Previous work concerning the use of everyday objects in tangible interaction as vehicles for intangible heritage is very limited. However, there is lots of research into how people use and design “everyday objects”. An interesting study compares Norman’s Design of Everyday Things (Norman, 2013), and Dourish’s Embodied Interaction (Dourish, 2004) to conclude that everyday designs (intentional modifications of everyday objects by their users) are instances of embodied interaction. Through this conclusion the researchers discuss how everyday objects are more familiar to users. As everyday objects become more and more familiar, they come to have more perceived affordances and begin to embody tacit knowledge (or the users gain tacit knowledge about the objects) (J Waddington & Wakkary, 2018). This makes sense in our context through the following Dourish quote: “Embodiment is the property of our engagement with the world that allows us to make it meaningful…embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts”. These ideas support the concept that because these everyday Musqueam belongings are relatable, they can
more easily embody meaning for their users. Additionally, previous studies have shown that designers can evoke cultural forms as a means to tap into users’ cognitive, physical, and emotional resources, and that the use of familiar cultural forms can help to create meaningful experiences by cueing patterns of social activity (M. S. Horn, 2013; Saxe, 2015). Although these belongings may not be explicitly familiar to users, it seems plausible that their relatability told to us by users suggests they can evoke or represent similar patterns of social activity, which could lead to increases in perceived affordances and embodiment of new tacit knowledge.

This finding is a physical property of belongings that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system. It also helped them to experience Musqueam culture and values that were embedded in the way they interacted with the system (RQ1).

6.1.2. Fidelity of Replicas to the Original Belongings

Interview results indicated that using faithful reproductions of the original belongings as tangible interface elements helped visitors to consider the history of real people and real belongings. While handling and using them, visitors considered properties of the actual belonging that was being reproduced, rather than those of the replica (see section 5.2.1). They also considered how the original belonging was made, including: who might have made it, the techniques they might have used, the reasons they might have needed it (see section 5.3.5). Using faithful reproductions can help visitors to more easily access and understand the information being taught. It can also help them to connect the information directly to a tangible (in the grammatical sense) concept. Additionally, it helped visitors to understand the veracity of the culture and the belongings they are handling (i.e. these are real things that actually exist and were/are part of real peoples’ lives). Visitors connected this to the large amount of knowledge contained within Musqueam culture. It helped them to understand the work ethic, skill, knowledge and dedication required to make the ancient belongings. It also created a bridging point to understanding and comparing how some knowledge and values may have been lost or changed over time, and how some have not.

Previous work in this area is sparse. There is no known research that has specifically evaluated the importance of the fidelity of replicas used for tangible
interaction in museum contexts – this is definitely a good area for further research. Many tangible systems use abstract objects/tools (e.g. magnifying glass) which might be realistic, but have metaphorical connections to the digital components (A. N. Antle, Bevans, et al., 2011). Others use lo-fi reproductions of objects (esp. 3D printed) with literal connections to the digital components.

There is one study whose abstract suggests the evaluation of using a “physical mock-up of a museum artefact” for 3D spatial input in a VR environment, but I have been unable to obtain a copy of the report (it was referenced in another paper; I found a copy of the abstract but have yet to track down a copy of the paper). That abstract of that study describes how the paper explores how technological fidelity affects perceptual fidelity and the further effect on memory schemas for object recognition in VR (Mourkoussis et al., 2006).

There has been some work in the area of faithful reproductions in virtual and multimodal environments, especially for “virtual object presence”. However, these studies typically use lo-fi physical tangibles to interface with/control hi-fi digital models (usually scanned), and then evaluate the importance of the fidelity of the virtual/digital model (Oosterlynck et al., 2004; Petridis, Mania, Pletinckx, & White, 2006; White, Petridis, Liarokapis, & Pletinckx, 2007).

This finding is a physical property of belongings that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system. It also helped them to experience Musqueam culture and values that were embedded in the way they interacted with the system (RQ1).

6.1.3. Breaking Social Practices

Interview results indicated that breaking social practices, especially those between visitors and artifacts in museums, fostered curiosity and respect from visitors. For example, only museum staff and curators can normally handle artifacts. Breaking this practice immediately supplied a sense of realism to the system.

Even though the tangibles in the system were replicas, we, as designers, wanted visitors to think about them as if they were real. We carefully considered and discussed techniques, such as using the museum cart with specimen baggies for
storage, to help visitors suspend their disbelief that the belongings were not just replicas. Even if the visitors knew that these were not real (some did and some didn't), users were generally able to accept them as convincing analogues for real belongings (see 5.2.2). Helping visitors to perceive the belongings as real allowed us to break social practices surrounding who is normally allowed to handle museum artifacts. For instance: it is a common social construct (and often an explicit rule) that one does not touch artifacts in a museum. They are usually old and delicate, and often priceless. Typically for the sake of preservation, we can observe them behind glass or at a distance, but we do not touch.

As a team, we intentionally designed the contrast between this socially engrained practice with an implicit invitation to pick up and handle the belongings. This was also backed up by an explicit invitation to pick up and use the belongings once a ring was placed on the table.

There was no docent present to supervise, and no way to ask permission. There were no physical constraints on the belongings; we showed trust and respect toward the visitors by presenting the belongings as if the visitors had the authority to view and handle them. This helped visitors to, in turn, respect the replicas and the system as if they were interacting directly with elements of Musqueam culture (see 5.2.2, 5.2.3). As an additional indicator of respect, the designers were surprised to find that over the course of approximately one year of use, not a single belonging replica was lost or stolen. Being allowed to handle and use the belongings broke existing social norms. Placing this confidence in our visitors was one aspect of how we designed the system to embody respect.

As a consequence of this setup, the belongings (usually on the cart) became the primary access points to enable users to join in on the shared system (Eva Hornecker et al., 2007) (see also 6.2.1). A selected belonging became the visitor’s key to entry as well as a social indicator of interest in joining in. Some have suggested that users of tools or utensils in social settings gain a sense of ownership over that tool; a feeling or idea that it temporarily belongs to them (aka the “endowment effect”). This concept has also been mapped to the field of tangible interaction (Speelpenning, Antle, Doering, & Hoven, 2011; Thaler, 1980). Consider the utensils at a table setting when dining at the house of a friend. When you sit at the table, that becomes your seat. The fork and knife are your fork and knife. You might even say, “my fork is dirty”. This fork doesn’t actually belong to you, but you gain a sense of temporary ownership of it (A. Antle, 2018). It seems
plausible that the visitors’ sense of ownership over the tangible belonging replicas that they used, helped them to connect with the actual belonging it represented on a deeper level, or even to gain an empathetic connection to the people who did/do use it.

Visitors experienced feelings of connection through handling the belongings – they were able to imagine making and/or using the ancient belongings. Handling belongings also slowed down interaction with the system. Through simultaneously learning about an object while using it to control the system, along with walking back and forth between the cart and the table, visitors were forced to slow down a little, which afforded extra time to think a little harder about what they were doing and learning. Although one might argue that this effect is the same with any tangible system (and no specific measure of it was taken during this study), it is plausible that the effect is greater when the tangible objects are a subject of instruction. In this case, visitors must balance using the device as an interface element with studying it as a real-world artifact. Additionally, handling an object while reading about it made the copy of the written material more meaningful for visitors. (see 5.2.3)

This area of simultaneously reading about, hearing about, exploring a digital interface, and handling an artifact could have some overlap with cognitive load theory and embodied cognition, especially in areas regarding alternate perspectives and memory. Because the tangible objects and subject matter are so closely tied, it is possible that learning a concept through this experience-based system engages multiple simultaneous cognitive pathways, or off-loads some information/processing onto the system, or allows users to mentally project data onto the physical artifact. Alternatively, because handling accurate replicas helped visitors to deeply realise that there are actual people connected with these belongings, they may have experienced the concepts they were learning from a shifted perspective, and learned, understood, or responded to interview questions from a point of view that they normally wouldn’t have. It is also conceivable that being allowed to handle replicas helped visitors to internalise/remember what they were learning through real-world experience with the objects they were learning about. However, these statements are somewhat speculative and I only mention them to suggest areas of further research.

Previous work around social practices and tangibles has focused on interactions between users. For example, as a way to facilitate group interaction (A. N. Antle,
Bevans, et al., 2011; M. Horn et al., 2012) or for conflict resolution (Olson, Atrash Leong, Wilensky, & Horn, 2011). There has been extensive work in the area of social practices and behaviour of visitors in museums (e.g. (Ellenbogen, Luke, & Dierking, 2004)), but nobody has explicitly studied how to leverage social practices, between users and the system, as part of embodied interaction.

This finding is a physical property of belongings that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system. It also helped them to experience Musqueam culture and values that were embedded in the way they interacted with the system (RQ1).

6.1.4. Ancient-Modern Contrast

Interview results indicated that using both ancient and modern belongings in the system helped visitors to understand the continuity of Musqueam culture (including the knowledge that it is a current living culture). It also helped them to think about Musqueam people and cultural empathetically (put themselves “in the shoes” of Musqueam people). Ancient and modern belongings were contrasted and compared in the system in many ways, including through interactive activities, through their placement on the museum cart, and through content/stories. Modern objects seemed especially to attract visitors to the exhibit (see 5.2.4, 5.3.3, 5.3.5). They expressed immediate curiosity about how these “normal things” that they might see in their everyday lives could relate to the exhibit. Some belongings stood out as apparently obvious or surprising mismatches with other belongings (e.g. Coke Can) due to their familiarity to visitors, while others may not have been immediately clear or familiar without further inspection (e.g. Tide Chart, Status Card).

Comparing ancient and modern aspects of Musqueam culture is how we framed a large part of the interaction design in the belongings system (i.e. once users placed a belonging in a ring on the table, they could either learn directly about that belonging, or choose to compare it to either modern practices or to its corresponding ancient/modern counterpart).

Did these comparisons need to be tangible objects? Would photos have had the same effect? I suspect that if we could have used very large or striking photos of some
of the more surprising belongings, the initial impact might have been similar or even stronger. However, the strength of using tangible belongings comes through their physicality. Physical objects bridge abstract and concrete ideas/meanings, they help users to shift between experience and reflection (which is important for learning), and they force body movement which also helps to switch between experience and reflection (Bakker et al., 2012). Learning about an object from a digital system by using that object to interface with the system, maps meaning directly to that object through embedded values and concepts (see 5.3.3, 5.3.5). Each time a visitor picked up an object, they were given significantly more opportunity to relate it to themselves or contemplate it in some other way, as compared to a photograph. This can before they even begin to use the object as in interface controller. As the visitor uses the object to explore and learn the values and concepts presented in through the content, interaction, and context of the system, the object itself comes to embody them. I doubt it is possible for an object to inherently embody a value when presented to a person who has not yet learned about that value OR the object. However, as they use it to interact they begin to create those connections through bodily experiences, participation, [socially] situated learning, perception, and reflection.

This finding includes both physical properties of belongings and physical-digital relations in the system. They both helped users to understand Musqueam culture and values that were being explicitly taught through content in the system. They also helped users to experience Musqueam culture and values that were embedded in the way they interacted with the system (RQ1, RQ2).

6.2. Established Findings

Some of my findings, discussed in detail below, can already be found in the existing body of HCI literature. They are:

1. The design strategy of providing visitors with quick access to straightforward information through multiple access points lowered entry barriers.

2. The design strategy of providing visitors with multiple pathways and no predetermined outcomes helped them to understand the breadth of information available and added value to what they were learning.
3. The design strategy of giving information to visitors in incremental layers helped them to build on new knowledge, create deep meaning within a big-picture understanding, and map meaning back onto the tangible belongings.

4. The design strategy of challenging visitors through a mix of obvious and ambiguous connections helped them to understand the value of the knowledge that was being given to them.

6.2.1. Quick Access

Interview results indicated that giving users multiple entry points with direct information immediately attached, lowered entry barriers. This allowed multiple visitors to use the system simultaneously, and to start learning quickly. The system had no orientation, and few instructions. A visitor’s first successful interaction immediately revealed clear information about a physical belonging that the user already had handled. I found that quickly learning something about the real objects we used as tangibles, helped users to gain a baseline of information in order to build a foundation for new knowledge (see 5.3.3, 5.3.4).

This finding also relates very closely with Hornecker’s concept of Embodied Facilitation (Eva Hornecker, 2005). Embodied Facilitation is the idea that a system can facilitate user movements, learning patterns, usage options, and collaboration through its physical and digital structures. It allows designers to focus and subtly direct group processes in tangible systems. We leveraged two key concepts from this idea: Embodied Constraints, and Multiple Access points (Eva Hornecker & Buur, 2006).

Embodied constraints allow system designers to ease and limit activities through physical set up of the environment. We utilized this concept by allowing users to freely handle physical belongings (as many as 12 visitors could each handle/control a belonging simultaneously). However, we also required the use of a physical ring in order for a belonging to be recognized on the table (up to two could be used simultaneously). We used this ring to intentionally limit the amount of data visible and activities happening on the table at any given time. The primary reason for this was real estate (i.e. our screen was not that big); we needed to limit the amount of simultaneously displayed information in order to keep both inputs and outputs clear and open. This setup forced users to work together in one or two distinct groups, of one to an undefined number of members each. It was completely feasible for one person to work alone, but it was
equally feasible for all the members of small groups to have similar levels of control. Once a belonging was placed in the ring, it could be swapped out by anyone. The belonging + ring combination could also be moved by anyone. Additionally, the physical-physical matching activity (Teachings) especially afforded two or more people working together to find a match as it required two simultaneous belongings, plus had a good chance of swapping at least one out multiple times.

Access points are the options available to visitors to be able to access and manipulate the required objects used in a tangible system. Multiple Access Points refers to a distribution of these objects to distribute control, keep individuals from taking over control, and lower thresholds for shy people (Eva Hornecker & Buur, 2006). Every belonging in the system had equal hierarchy. The only limitation in this aspect was (as mentioned above), only two rings could be used at once, and one was required for a belonging to be recognized by the table. However, due to physical size limitations, it was impossible for more than a few people to be around the table at one time. The system allowed a second person or group to jump in if one was already there. The cart of belongings offered a third choice for visitors to pre-select a belonging to start with once a ring became available. It was also difficult for a single person to take control of a ring, as they often needed to let go of either the ring, the belonging, or both in order to interact with the touch controls or to seek a new belonging for a ‘teachings’ matching activity.

This finding is a physical-digital relation that helped users to understand the Musqueam cultures/values that were being explicitly taught through content in the system (RQ2).

6.2.2. Multiple Pathways

Interview results indicated that giving users multiple pathways through the system helped them to understand the breadth of information available about Musqueam culture. It also added value to the information they were learning through a sense of discovery (see chapter 5.3.1).

This design technique in this finding is very similar to an existing model of game play entitled Emergent Dialogue (from which I’ve borrowed the phrase ‘Multiple
Pathways’). There are two key factors to how this theme relates to the design markers from the Emergent Dialogue model:

First is that visitors are free to explore the system in any order and direction that they choose. There are several initial entry points (6 ancient belongings, 6 modern belongings, 2 rings), and several actions to take with each belonging (see [flowchart] chapter 3.1). Within each of these actions there are several pages/cards of information that can be optionally explored. The order/direction in which they are explored is not predetermined. In total, there are over 200 information cards in the system and a difficult-to-determine number of pathways to access each of them. This aligns well with the “Multiple Pathways” design marker from Emergent Dialogue.

Second is that visitors are free to determine their own stopping point. There is no immediately clear way of “winning”, aside from, perhaps, accessing and understanding every piece of information in the system. But, there is no user-visible mechanism to track that exploration as progress. On the other hand, the system does track certain indicators of progress per belonging per session that determines visitors access to the unique video for each belonging. This is indicated to the user as the “progress ring” and has actually be recognized as a limitation of the system (see 5.4) In the end, users are free to decide for themselves when they are finished. There is no penalty or indicator of incompletion. There is also no single predetermined outcome. This aligns well with the “Outcomes” design marker from Emergent Dialogue.

So far as I am aware, the Emergent Dialogue model has never been used as a tool for designing embodied values in tangible interaction. In this case, although I recognized it in hindsight, it could have been a useful design tool. Although this framing was not actively used during the design process of either version of the Belongings System, Antle was one of the primary developers of that model, and was also one of the primary researchers of the Belongings Project. It is plausible that some of her design input was rooted in her experiences with Emergent Dialogue.

It is also worth mentioning that the previous study included a design recommendation entitled: “Non-linear Explorations” that is very similar to this finding. Although I don’t think there is anything incorrect about this, the idea is so similar to the
existing theme of Multiple Pathways within the Emergent Dialogue model, that I’ve decided to use it instead.

This finding is a physical-digital relation that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system, as well as a way to experience culture and values that were embedded in the way they interacted with the system (RQ2).

6.2.3. Incremental Layers for Meaning

Interview results indicated that giving information to users in incremental layers helped them to build on new knowledge, create deep meaning within a big-picture understanding, and map meaning back onto the tangible belongings (see 5.3.3, 5.3.4).

This finding, critically, indicates that there might be a loop that happens in step with mapping meaning. It starts with handling an object, then using it to learn about the itself, then using it to learn about a culture through the content (stories, values, issues, etc. explicitly taught through content), to mapping data gleaned from that content back onto the tangible object (meaning, values, etc.), then back to handling. This object now has new meaning and value for the user as s/he uses it to continue to control the system. It is likely that this loop isn’t just a one-time event, but an iterative sequence that is constantly cycling as the user is exposed to new layers of information. In other words, objects can come to embody new information incrementally during and throughout their being used as tangible objects.

I suggest, based on this and previous findings, that users also map implicitly learned values onto the tangible during this loop (not just explicitly taught information). These implicitly learned values are values that we, as designers, have attempted to embody through the interaction, rather than in the content; i.e. values that users experienced directly in the system or gleaned from the way that they used the system.

Previous research in this area mostly applies to theories about learning information incrementally. This is far from a new idea and, as a subset of the belongings system, closely follows the concept of constructivist assimilation (Ackermann, 1996; Piaget, 1977). Visitors are expected to take an active approach to learning; they
incrementally combine new information with their existing knowledge in order to form a new schema of Musqueam culture, people, and values.

This finding is a physical-digital relation that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system, as well as a way to experience culture and values that were embedded in the way they interacted with the system (RQ2).

6.2.4. Challenging Visitors

The design strategy of challenging visitors through a mix of obvious and ambiguous connections helped them to understand the value of the knowledge that was being given to them. This value was understood through working hard, exercising patience, feelings of respect, feelings of missing out on important knowledge, and feelings that earning knowledge is a privilege. It also caused them to slow down and reflect, which helped them to gain additional insight (5.3.3).

Uncertainty is often seen as a problem to be overcome, but it is something that can be exploited to help users to pause, reflect, and gain insight (Hallnäs & Redström, 2001; Rogers & Muller, 2006). This might seem to contrast with the Quick Access findings (see 6.2.1), but the two can work together. Quick Access is designed to pique interest in the system and help the visitors to feel comfortable using it. Once they have been given a ‘taste’ of the information available in the system, and have been given a foundation for new knowledge, we can intentionally slow them down in order to help them reflect upon and internalize deeper information and values as they progress (see 5.3.3). We accomplished this primarily through ambiguity.

The first version of the system made heavy use of informational ambiguity (Gaver et al., 2003) through minimal instructions (alongside technology novel to a vast majority of users) to portray that cultural knowledge is not given away freely and that it must be earned. However, resulting usability limitations of this system led to the redesign and, subsequently, this study. In the second iteration, we wanted to portray the same idea but needed to do it in a different way. We first implemented good feedback and simple instructions to overcome basic usability issues. We then focused more on leveraging relational ambiguity (Gaver et al., 2003) through a mix of logical and ambiguous
contrasts between ancient and modern aspects of Musqueam culture (see Chapter 5.2.5). The ambiguous contrasts weren’t illogical or random, just not immediately obvious. This relational ambiguity was, more or less, present in the first system, but on top of the ambiguity of information, most users didn’t progress far enough into the system to encounter it (Muntean et al., 2017).

Although it seemed too difficult for some users (see 5.3.2, 5.3.3), this could always be attributed to impatience, as any activity could be solved by persistent guessing. We actually hoped that impatient or undetermined visitors would not progress past a certain point, as it was a core requirement of our design to embody the idea that cultural knowledge must be earned (even if it was only through persistent guessing – that counts as work). If anyone did progress to the point of unlocking a video, then they inherently demonstrated the requisite patience, respect, dedication, understanding, and/or desire to understand in order to be allowed to receive that information.

This finding is a physical-digital relation that helped users to understand Musqueam culture and values that were being explicitly taught through content in the system, as well as a way to experience culture and values that were embedded in the way they interacted with the system (RQ2).

6.3. Design Guidelines

The following eight design guidelines are based on the findings from this study, which are based on qualitative evidence from semi-structured interviews. Researchers interviewed visitors immediately after they used the second revision of the tangible tabletop system, ᖲCooldown – Belongings, in the MOA at UBC.

The first four findings are more specific versions of findings from the previous study. They are unique within the greater body of work and will need further study before they should be considered as established guidelines. The collaborative process that grew out of long-term established relationships, such as that between MOA and Musqueam, made this kind of work possible. These findings may not be reproducible in other design processes; this was a unique opportunity. Because of this and other contextual factors mentioned previously (see Chapter 2), some of these findings may be contextually specific and may not generalize easily to other projects within different
contexts and design processes. Because no design guideline can be generated in isolation, each designer will hopefully consider the context in which these guidelines were developed and adapt them to inform their own design decisions.

The last four guidelines are strongly supported by existing research and can be considered further evidence of previously established concepts. Because they are duplicated and less contextually dependent, they can probably be used as actionable guidelines which may lead to intended outcomes. As with any rigorous design process, if very specific outcomes are desired, each critical design decision should be evaluated and iterated upon as required.

Again, these guidelines are meant to be used as a set of tools or consideration points as part of the design process of tangible interaction based systems. More specifically, they should be helpful in determining how to embody specific cultural values in tangible interaction based systems in museums. This should not be considered a complete set of guidelines, a framework, or a design manual for tangibles; these guidelines are specifically framed around techniques for portraying and embodying cultural values for museum (or museum-like) educational installations. Additionally, these guidelines were developed using a tangible tabletop and some ideas may not translate well to other technologies. However, I hope that they might be useful for any designers who need to consider ways to portray (with respect) the values and culture of a specific group using any tangible technology.

1. Use everyday objects rather than extraordinary artifacts to create tangible objects. This helps users to relate to the culture they are learning about.

2. Use faithful reproductions of artifacts, rather than coarse or metaphorical approximations, to create tangible objects. This encourages users to consider the history of real artifacts that belong(ed) to real people.

3. Break existing social practices between visitors and artifacts in museums. This fosters curiosity and respect from users.

4. Use replicas of both modern and ancient cultural artifacts to create tangible objects, if applicable. This helps users to connect with the culture they are learning about, and can also support their understanding of the continuity of a culture from the past through to the present.
5. Provide users with quick access to straightforward information through multiple access points. This lowers entry barriers and helps them to gain a baseline of information in order to build a foundation for new/additional knowledge.

6. Provide users with multiple pathways and no predetermined outcomes. This helps them to understand the breadth of information available and can add value to what they are learning by fostering a sense of discovery.

7. Give information to visitors in incremental layers. This helps them to build on new knowledge, create deep meaning within a big-picture understanding, and map meaning back onto tangible objects.

8. Challenge visitors through a mix of obvious and ambiguous connections. This helps them to place value on what they are learning, and can compel them to slow-down and reflect.
Chapter 7.

Conclusions

7.1. Summary

This thesis describes an exploratory field study that was used to evaluate the design of a tangible tabletop exhibit in a museum. The system built upon, and was only possible because of, the collaborative efforts of many experts that emerged from long-term relationships. The designers and curators of the system attempted to embody cultural values in the way people interacted with the exhibit. It used replicas of ancient and modern Musqueam artifacts, which we refer to as Belongings, as tangible objects. As part of the evaluation, I identified ten design themes from which I developed eight design guidelines.

I used the following two research questions to frame and guide this work:

RQ1: What are the important physical properties of the belongings that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

RQ2: What are the important physical-digital relations in the system that affected visitors’ understanding/experience of Musqueam culture and/or values, if any?

A previous study, based on the first version of the system, identified some barriers and usability issues. A smaller design team made several changes to the system based on those findings. I ran this second study to evaluate the second design iteration of that system. I evaluated the system by interviewing 20 adults who were approached immediately after they completed interacting with the exhibit in a public museum setting. I analyzed the transcribed interview data with a similar thematic analysis process to the first study, using an open-coding scheme, and two independent analysts.

The results of this study show some promising techniques to help designers embody cultural values in tangible interaction. Four of the guidelines I developed are
additional support for established guidelines. However, four of them are more specific versions of findings from the previous study (Muntean et al., 2017), and appear to be otherwise unique within the field of embodiment in tangible interaction. They are so new that they require reproduction, or might be contextually dependent (see Chapter 2, 3.1), or both. For now, they should be viewed as design considerations and merit further research. These are:

1. Use everyday objects rather than extraordinary artifacts to create tangible objects. This helps users to relate to the culture they are learning about.

2. Use faithful reproductions of artifacts, rather than coarse or metaphorical approximations, to create tangible objects. This encourages users to consider the history of real artifacts that belong(ed) to real people.

3. Break existing social practices between visitors and artifacts in museums. This fosters curiosity and respect from users.

4. Use replicas of both modern and ancient cultural artifacts to create tangible objects, if applicable. This helps users to connect with the culture they are learning about, and can also support their understanding of the continuity of a culture from the past through to the present.

Due to a relatively small sample size, single study, unique setting, and first appearance, these guidelines should be considered preliminary and merit further research.

7.2. Future Work

In this section I will propose further work on the Belongings System, and then I will discuss further potential research.

As this is only the second major iteration of a fairly complex tangible interaction system, there are several changes that could be made to the Belongings System, apart from specific usability and hardware issues listed in section 5.5.1. One of the features we originally intended to include was audio. Because hən̓q̓əmin̓əm̓ is a fairly rare language, we wanted to expose people to how the hən̓q̓əmin̓əm̓ words they were seeing are pronounced (in the 2016 Canada census only 475 people reported halkomelem as their mother tongue – the downriver dialect, hən̓q̓əmin̓əm̓, is the mother tongue for a
subset of these people (Government of Canada, 2017)). There are several possible ways to incorporate this, which could include, for example, tapping on words to hear an audio clip, or automatic playback triggered by certain events.

Novelty is an ongoing issue with unique or unusual interactive systems. One possible solution would be to see how a group of users familiar with tangible tabletops might respond. This could help to isolate the design of the system by minimizing novelty as a variable.

One important limitation discussed in section 5.5.2, is that we didn’t get the opportunity to test a completed system with members of the Musqueam community. A future study or collaboration with members of this community could prove very valuable.

Another important limitation of this study was that it evaluated a very large age category (18+) as a single group. It could prove valuable to evaluate the system by smaller age segments. This could help to determine how different generations, who have grown up with different normalized technologies respond to this novel approach to using an uncommon technology. It might also help to evaluate whether some usability or other issues with understanding are generally isolated by age, in order to help determine underlying sources.

Finally, as mentioned previously, Design Guidelines 1 – 4 have been identified as preliminary findings. Before they are implemented concretely as part of a design practice, they merit further evaluation and replication in order to verify their strength and applicability.

### 7.3. Contribution

This thesis extends and partially replicates our work from the first study (Muntean et al., 2017), including a redesign (based on the results of the first study) of the interactive tangible tabletop system. The main contribution is a new study, based on two new research questions that I developed in response the first study. This study revealed some new themes and some existing themes compared to previous works. The findings also helped me to derive more specific design guidelines about how to support embodied cultural values in tangible interaction than was possible in the first study.
This work expands on previous work within the fields of tangible interaction and intangible cultural heritage and extends the previous study (Muntean et al., 2017), through 4 preliminary guidelines:

1. Use everyday objects rather than extraordinary artifacts to create tangible objects. This helps users to relate to the culture they are learning about.

2. Use faithful reproductions of artifacts, rather than coarse or metaphorical approximations, to create tangible objects. This encourages users to consider the history of real artifacts that belong(ed) to real people.

3. Break existing social practices between visitors and artifacts in museums. This fosters curiosity and respect from users.

4. Use replicas of both modern and ancient cultural artifacts to create tangible objects, if applicable. This helps users to connect with the culture they are learning about, and can also support their understanding of the continuity of a culture from the past through to the present.

The work herein also replicates and expands on the findings of previous studies through the following guidelines. I’ve referenced a summarizing existing theme and typical publication(s) for each. See section 6.2 for detailed discussions.

5. Provide users with quick access to straightforward information through multiple access points. This lowers entry barriers and helps them to gain a baseline of information in order to build a foundation for new/additional knowledge.

Entry and Access (Eva Hornecker et al., 2007)

6. Provide users with multiple pathways and no predetermined outcomes. This helps them to understand the breadth of information available and can add value to what they are learning by fostering a sense of discovery.

Emergent Dialogue (A. N. Antle et al., 2014)

7. Give information to visitors in incremental layers. This helps them to build on new knowledge, create deep meaning within a big-picture understanding, and map meaning back onto tangible objects.

8. Challenge visitors through a mix of obvious and ambiguous connections. This helps them to place value on what they are learning, and can compel them to slow-down and reflect.

Slow Interaction and Ambiguity (Gaver et al., 2003; Hallnäs & Redström, 2001)

These findings have both helped to validate the Belongings system as a research instrument, and have confirmed and expanded upon the findings of the first study. Although the first four guidelines are preliminary, this replication shows promise and is evidence to justify further study. All eight design guidelines might help designers developing tangible interaction systems, especially in the context of museums, who are trying to help visitors understand intangible cultural heritage. I hope that any resulting systems can help visitors gain a deeper understanding of the often hidden values and meanings behind the vast collections of tangible and intangible cultural heritage in museums.
References


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Appendix A.

CHI Paper: *Designing Cultural Values into Interaction* (CHI 2017)
Designing Cultural Values into Interaction

Reese Muntean¹, Alissa N. Antle¹, Brendan Matkin¹, Kate Hennessy¹, Susan Rowley², and Jordan Wilson²

¹Simon Fraser University
Surrey, Canada

²University of British Columbia
Vancouver, Canada

ABSTRACT
In this paper, we highlight possibilities for designing intangible cultural values into interactions with technologies in heritage spaces. We do this specifically through the design of ʔelwə̱n — Belongings, an interactive tangible table installed in a cultural heritage museum. The tabletop was collaboratively designed to communicate complex and narrative information and values about Musqueam culture. Rather than focusing only on content and interface design, we wanted visitors to also experience Musqueam values through their interactions with the system. We describe our value-sensitive design process, present five interdependent design goals, discuss the design strategies that enabled us to meet these goals, and evaluate our approach through a user study. From our design process and evaluation we offer recommendations for designing values into interactions more generally and for tangible interactions specifically in ways that support visitors’ experience and understanding of specific cultural values through technology.

Author Keywords
Intangible cultural heritage; indigenous heritage; museums; tangibles; digital tabletops; value sensitive design.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces, Evaluation/Methodology.

INTRODUCTION
Researchers are increasingly exploring how human values take shape in our digital technology (e.g. [19, 21, 44]). While initially these explorations examined universal values, culturally specific values can also be designed into digital systems and our interactions with these systems [10]. At the same time, museums continue to incorporate technology into exhibits, allowing visitors to engage with information in different ways and in greater depth. Digital technologies are also being used to move beyond a focus on tangible heritage objects to address the challenges of safeguarding intangible cultural heritage—the traditions or living cultural expressions that are passed on from generation to generation [43, 62]. In this paper we highlight possibilities for designing intangible cultural values into interaction in heritage spaces. We do this specifically through the design of an application for a multi-touch tangible table. Much of the work in this area has been focused on how and what visitors learn through interaction with tabletops (e.g. [2, 3, 4, 14, 15, 34]), how to design to support visitor engagement (e.g. [5, 8, 40]), and issues around initiating and sustaining interaction in public spaces (e.g. [23, 35, 37]).

The intersection of these research domains remains largely unexplored, yet holds great potential for using interaction design to convey cultural values and presenting intangible elements of culture in interactive museum exhibits. How do we design to convey and allow others to experience intangible cultural ideas, such as values?

In this paper we explore how collaborative interaction design could convey such values, driven by our research question: What are effective design strategies that enable visitors to directly experience cultural values while they interact with Indigenous knowledge using a tangible tabletop system? We examine the design goals, our design strategies related to each goal, and the evaluation of ʔelwə̱n — Belongings, an interactive tangible tabletop at the Museum of Anthropology (MOA) at the University of British Columbia (UBC) which uses replicas of belongings from cósnaʔom (an ancient village site where modern day Vancouver, Canada is now located) with Musqueam intangible cultural knowledge and was part of the cósnaʔom, the city before the city exhibition exploring this history through the voices of Musqueam community members. From our analysis we offer generalizable design recommendations that can be used by researchers and designers of tangible interaction who want to support users in experiencing intangible elements of culture.

We will introduce ourselves here to situate ourselves as the authors, curators, researchers, and designers. We, the authors and faculty members and students from UBC and Simon Fraser University (SFU), comprised the core development team. Rowley at the time was co-head of the
Department of Anthropology at UBC, Associate Professor, and Curator of Public Archaeology at MOA. She has significant experience working collaboratively with the Musqueam Indian Band, and she and Wilson, a Master’s student at UBC and a member of the Musqueam Indian Band, were the co-curators of MOA’s exhibit. Our SFU team included Hennessy, an Assistant Professor with a background in anthropology whose own work is focused on the collaborative development of culturally specific new media applications and installations, and Antle, an Associate Professor who has expertise in tangible computing and embodied interaction. Matkin was a Master’s student under Antle, and Muntean was a Master’s student under Hennessy and the project manager of the tabletop. Our team also included two undergraduate students who had previously completed work with Antle. While the UBC team provided the content and museum-related support, the SFU members focused on the technical aspects of development, interaction design, fabrication of the physical aspects of the tangible interface, and the programming of the tabletop. All team members participated in the overall activity design of the table.

We begin this paper with a summary of related work, then outline our five interdependent design goals and describe the design strategies we employed to achieve these goals. Next we present our visitor study along with our results and design recommendations derived from what we have learned about designing cultural values into interaction.

RELATED WORK
Our work is situated in the areas of Value Sensitive Design, collaborative design with Indigenous communities, cultural heritage in human-computer interaction, and museum tabletop exhibits.

Value Sensitive Design
Value Sensitive Design (VSD), developed by Friedman, Khan, and Borning [19, 21], considers how human values are embedded within technologies and how these technologies can in turn shape values. Instead of the original, universal “values of human import” of VSD [20], here we look at certain cultural values that the design team carefully considered before the specific and specialized system was developed. Le Dantec et al. called for such an extension of VSD [44], recognizing that the classification of values was limiting and the “ex post facto value analysis” allowed for examining how systems affect users but not for informing system design. Borning and Muller later reflected on the next steps for VSD [10]. In this paper we take up three of the four topics discussed: addressing the universal vs. culturally specific values issue as an empirical one, strengthening Musqueam voice in publications, and making our own voices as researchers and designers more clear. Durrant et al. drew upon concerns from VSD in their research on values in curating videos in a human rights archive [18]. They noted a particular challenge for interaction designers is to enhance cultural engagement with sensitive archive materials while supporting empathic interactions, a challenge we take up in a different context here.

Collaborative Design with Indigenous Communities
Designing with Indigenous communities has similarities to and divergences from theories of participatory design and co-creative experiences (e.g. [7, 39, 40, 55, 58]). We see our collaborative process as more closely related to ideas of post-colonial computing as examined by Irani et al. and its response to uneven economic and power relations and cultural epistemologies [38]. The authors mention examples of information management systems as an intersection of cultural understandings and technology [61, 63] while grappling with issues of cultural property ownership (e.g. [11]), and we see our work as extending these ideas of creating technologies that communicate traditional cultural knowledge and allow for multiple ontologies and worldviews (e.g. [13, 48, 60]). The collaborative models displayed by museums and Indigenous communities (often in developing databases for cultural heritage) (e.g. [29, 31, 32, 33, 53, 54, 57]) informed our design process, though our work here explores new technologies for communicating this cultural information to the public.

Intangible and Digital Cultural Heritage in HCI
While the study of cultural heritage is an established domain in HCI research (e.g. [16, 22, 28, 46, 66]), the study of intangible and digital heritage remains underexplored in HCI (see [9]). This is not to say that no one is conducting such research. There are authors discussing new media and museums in the digital age (e.g. [41, 51]), looking at the digitization and safeguarding of cultural heritage [1, 45, 47, 52], technology for the museum space [27, 42], and connecting different forms of heritage such as natural, tangible, and intangible [24, 30]. Giaccardi and Palen explain how evolving information and communications technology can allow multiple media and interactive technologies to work together for users to experience and think about cultural heritage differently [25]. Multimodal or cross-media interaction can facilitate the exploration of tangible and intangible aspects of heritage together and allow new ways to engage with specific cultural values. Indeed, there are many examples of collaborations with Indigenous communities on multimodal projects that allow for archiving, storytelling, and interacting with intangible cultural heritage (e.g. [37, 56]). Our work contributes to this space by exploring how we can use the unique features of tangible touch tables in particular to convey both tangible and intangible cultural heritage to museum visitors.

Tangibles and Tabletops in Museums
Researchers are studying the design and use of tangibles in museums for both navigating the museum itself (e.g. [12, 65]) or information in interactive exhibits (e.g. [17, 49]). One example by Horn describes an approach to tangible interaction in which designers can evoke “social constructions or conventions”, cultural forms such as counting systems, games, or currencies that often involve a
physical artifact (Horn suggests that a high fidelity reproduction of the original cultural form is necessary) [34]. Horn and others have shown that cultural forms can be used for interaction design to utilize users’ cognitive, physical, and emotional resources to increase usability and create meaningful experiences for users and observers [5, 34, 36, 59]. We extend this work, using cultural forms for interaction and experiencing values.

Mapping Place is an exhibit that introduces cultural concepts through the combination of a multi-touch table and an interface of physical objects [14]. It is based on a culturally specific storytelling device that utilizes beads, shell fragments, and carvings on a wooden board to guide stories and record history. The activity teaches the Luba peoples’ mapping practices and perspectives through embedded cultural logic and structure, though Chu et al. found that participants who received a lesson before interacting with the exhibit showed better conceptualization and utilization of abstraction and symbolism in ways more similar to the Luba [14]. We wanted create this type of background lesson in the system itself, thus preparing visitors to experience values through their interactions.

Hornecker presents a field study of the Tree of Life, an interactive multi-touch tabletop exhibit that allows visitors to access information through a question-answer dialogue [35]. The question-answer format did not engage users as deeply as hoped and there were not enough layers to allow users to delve deeper. Others have recommended design approaches that may alleviate these issues such as presenting activities that initiate construction and testing of hypotheses, discovery, and meaning making (e.g. [15, 35, 64]) and reward visitors for early successes as well as for persistence in exploring further content [2, 15, 23, 35]. A balance between drawing visitors in and enabling them to persist and gain deeper understandings is key [15, 23, 35].

**DESIGN REQUIREMENTS AND GOALS**

The ʔeləw̓kw̓ʷ — Belongings project emerged in the context of the long-term collaboration between MOA and the Musqueam Indian Band (described in greater detail in [50]) and was designed in conjunction with members of the Musqueam community. Our collaborative design process and focus on values was a result and continuation of this relationship.

During our first design meeting, we developed nine main goals for the project, including highlighting Musqueam voices which was central to the overall exhibition. This session allowed us to see where our personal goals (and values) were as curators, designers, and researchers. Our team’s interactions with the Musqueam Indian Band included representation at the Exhibit Advisory Committee meetings with Musqueam elders, visits to Musqueam reserve land to collaborate with community members on creating the photographic imagery, and incorporation of Musqueam language and values in our process. The Exhibit Advisory Committee was integral to ensuring that Musqueam’s voice and values drove the exhibitions. Rowley and Wilson were members of this committee and attended the weekly meetings, reporting on our work and asking questions on behalf of our ʔeləw̓kw̓ʷ — Belongings design team. Many images on the tabletop were taken by community members, but Muntean also visited Musqueam to take photographs. For example, Muntean and Wilson worked with the Musqueam Fisheries Commission to photograph the fish preparation process and develop the main tabletop image.

The development team worked to incorporate Musqueam cultural values, and even their hən̓q̓əmin̓əm̓ language, in the design process including all related documentation and communications, such as using Musqueam’s approved abbreviation for ʔəsənʔəm, əsnəm, in file names and even in the code written for the tabletop application. Another example of this focus on values is evident in the use of the term “belongings” in the title of the tangible table and throughout this paper. While belongings excavated from ʔəsənʔəm are more commonly referred to as “objects” or “artifacts”, the Musqueam see them as still belonging to the hands that created them. As such, we adopted the term ʔeləw̓kw̓ʷ, a hən̓q̓əmin̓əm̓ term meaning belongings, to discuss what has been removed from ʔəsənʔəm.

This collaborative design with cultural partners and the reflection upon cultural values throughout the process were so important that we consider them to be requirements for the design process. It is through this process that our goals and design recommendations developed. From the beginning of this process it was evident that Musqueam values and traditional knowledge were important to convey. Yet we wanted to move beyond descriptions of values and enable people to directly experience these values. Our commitment to this direction emerged early in the process and was likely a result of wanting to honor Musqueam’s intentions for the exhibition and representation of their culture [26] and our own desire as designers and researchers to push the boundaries of design. In addition to these two requirements, we agreed upon five interrelated design goals that we hoped, when met, would enable visitors to experience cultural values through their interaction with a tabletop system.

*Design Goal 1* [DG1]: *Draw in People*

In line with previous work (e.g. [3, 37]) our first goal was to draw in people to the space and initiate interaction with the table. Since the table was to be placed in a small alcove that was part of the larger exhibition, we needed a way to attract visitors into the space and encourage them to engage with our system.

*Design Goal 2* [DG2]: *Learn about Musqueam Culture*

At the simplest level, we wanted people to learn something new about the Musqueam people, culture, and identity both past and present. The curators noted that by displaying ancient belongings, visitors might mistake material culture to be the same as culture, resulting in a false impression that
Musqueam culture is only about the past. Our learning goal was for visitors to understand that Musqueam is a contemporary society that has existed in the region for thousands of years.

**Design Goal 3 [DG3]: Understand Richness of Belongings** Building on the basic knowledge in DG2, we also wanted visitors to understand the richness of information about the belongings, including how they were used and how common they were. In line with trends designing exhibitions for cultural heritage (e.g. [25]) and the notion of cultural forms [34], we wanted to display the belongings in such a way that people could interact with them physically rather than passively view them behind glass.

**Design Goal 4 [DG4]: Understand Complexity of Stories** Building on DG2&3 and addressing issues raised in [35] about lack of depth and the importance of understanding the complexity of value-laden content [3], we wanted visitors to understand some of the complexity of information related to belongings excavated from čəsəmʔəm. We envisioned visitors learning some of the many stories related to each belonging.

**Design Goal 5 [DG5]: Experience Cultural Values** Rather than telling visitors about culture values, our goal was to have visitors experience values through their interaction, adding cultural specificity to ideas from previous work that showed how enabling visitors to make their own interpretations about values through interaction had a greater impact than simply telling them about values [6]. Learning basic information about Musqueam culture through DG1-4 would provide context for visitors to experience values through interaction, similar to the prior lesson in [14]. We determined the values we wanted to focus on during the development process working with the curator and representatives of the Musqueam Indian Band. The most important value we wanted visitors to experience was that Musqueam cultural knowledge should be treated with respect. Other values included the importance of hən̓q̓əmin̓əm language, the acknowledgment of belongings as still belonging to the ancestors who created them, and that access to culture knowledge is not given freely but should be earned. Our goal was for visitors to experience these four values through their interactions with the table.

**SYSTEM DESCRIPTION AND DESIGN STRATEGIES**

- Belongings comprises a Samsung SUR40 table, three monitors, twelve replicas, and two activator rings. The physical installation occupies part of the exhibition space with three walls, with one monitor on each wall (See Figure 1). One monitor plays a series of photographs detailing the process of cleaning a fish. The remaining monitors are each associated with one of the ring tools. The table itself sits in the center of the space, displaying an image with a top-down view of a fish-cutting table. A rolling museum cart is nearby with twelve physical belongings for use on the table: six ancient belongings (celt, slate blade, cedar bark, net weight, decorated piece, and harpoon) and six contemporary belongings (Coke can, ice cube, quarters, keys, status card, and tide chart).

The monitors are intended to contribute to our goal of bringing people into the space [DG1]. The main monitor facing the gallery incorporates rich visuals with the slide show of a fish being cut and cleaned. The two side monitors display an image with all twelve belongings and play videos of Musqueam community members when visitors unlock special stories by exploring the belongings, thereby connecting tangible and intangible heritage.

**Figure 1. Museum setup ©Reese Muntean**

Salmon fishing is used as an overall theme for the table, because it has been part of the Musqueam way of life for thousands of years, supporting DG1 and DG2. The image on the table shows a fish cutting table surrounded by related contemporary tools. Different items appear in the image including the bloody fish, fish fillets, knives, an axe, a woodpile, an iPhone, an oilcan, a gas can, a fishing net, boots, pavement, and a tote of fish. While the image serves to bring people over to the tabletop and offer a sense of Musqueam identity, each of these areas of the image also matches one of the physical belongings.

The belongings sit next to the tabletop on the cart. Like cultural forms [34], the replicas of ancient belongings were designed to look and feel as similar to the originals as possible [DG3]. However by allowing visitors to learn about the ancient belongings by directly handling them physically we break with traditional social practices around museum artifacts, which are typically behind glass.

Because they would be handled, we made sure that the look, texture, and weight were as close as possible to that of the original belongings. With permission from the Musqueam Indian Band, molds of the original belongings in MOA were made and replicas cast. The molds and material allowed us to approximate the texture and weight of the originals. The replicas were hand painted to match the details and colour variations of the originals. For the modern belongings we used the actual items coated in resin or sealer. Using the belongings as system inputs required the use of fiducial markers on each belonging, so we modified them to be small enough that they would not distract from the belonging or hinder the use of the belongings on the table. The cart, too, was incorporated as part of this dedication to representing the belongings accurately. In museum storage, artifacts are kept in small plastic zip lock bags. On the cart, we placed the belongings...
on top of zip lock bags containing a slip of paper with an 
image of the replica and its name in hən̓q̓umɩ̓m̓iləm. 
The two wooden rings sit on the table and are painted to 
match the specific monitors. There are four hən̓q̓umɩ̓m̓iləm 
terms etched around the rings, which serve as activators for 
the belongings. The hən̓q̓umɩ̓m̓iləm is included here to 
reiterate the importance of traditional language as included 
in our goals, DG2 and DG5. 
Instructions are positioned on two sides of the table. The 
instructions include an illustration that shows how to put a 
belonging in the ring and text that explains the four 
ʔən̓q̓umɩ̓mɩ̓ləm categories on the ring. These categories are 
stem ʔən̓? (What is this?), tatalot (Understanding it), 
sn̓aʔeyx̱ (Teachings since childhood), and cyoh̓las (Having 
stories). When a belonging is placed in a ring on the table, a 
digital ring with the English translations of the hən̓q̓umɩ̓mɩ̓ləm 
etchings appears on the table around the physical ring. 
To access each category, visitors must complete different 
interactions, akin to small matching puzzles. The categories 
reveal different layers of information about the belongings 
as a way to convey the complexity of the stories that these 
belongings can embody [DG4]. This information appears 
on the table in the form of quotes from Musqueam 
community members, images, text, and historic documents. 
The activities required for each category take time and 
thought, and the correct answers are not always obvious. 
This was intended as a way for visitors to earn cultural 
knowledge and spend time engaging with Musqueam 
values. Once visitors complete the first three categories, 
they unlock a video of a Musqueam community member 
sharing their culture, stories, and lived experiences [DG5]. 

USER SCENARIO 
We will now walk through each of these categories to 
explain the interactions involved and give examples of 
specific belongings and the information connected to them. 
stem ʔən̓? (What is this?) 
To access basic information about a belonging’s function, a 
user must place a belonging in an activator ring on the 
tabletop. This activation of the belonging brings up cards on 
the table that explain what the belonging is and what it was 
used for. This simple interaction brings people into the 
activity [DG1] and communicates information about the 
physicality of the belonging [DG3]. Handling the belonging 
and accessing the basic information meets the goal of 
understanding the use and place of the belongings in 
everyday life. With the small stone belonging, visitors feel 
the weight and texture of the rock and learn that it is a net 
weight that was used to place fishing nets in the river. Once 
visitors have basic knowledge they can explore 
Understanding it or Teachings which add different layers to 
the information about the belongings [DG2-4] 
tatalot (Understanding it) 
When visitors touch the Understanding it section of the 
digital ring, dotted lines appear around hotspots on the table 
that correspond to particular belongings. The visitor must 
move the belonging and ring over the correct spot on the 
image to access information about a belonging’s 
importance and place in Musqueam life. 
Some connections are more obvious than others, e.g. the 
slate blade and the modern knife are both used for cutting. 
Other connections are more abstract and do not relate 
directly to the belonging’s use, like the Indian status card 
that pairs with the tote of fish because of the fishing 
regulations imposed on First Nations by the Indian Act. 
The information cards in this case explain how the fishing 
tradition of the Musqueam people has changed with the 
laws that have been imposed upon them. 

sn̓aʔeyx̱ (Teachings since childhood) 
Visitors can learn more about the belongings in the 
Teachings category by matching an ancient belonging to its 
contemporary counterpart. Rather than connecting a 
belonging to the underlying image, here visitors are asked 
to make connections between the ancient and modern 
physical belongings. Through this activity visitors learn 
about continuity of Musqueam culture. 
When a visitor touches the category on the digital ring, a 
black circle appears just outside the ring. Visitors place the 
matching belonging in the circle. The Coke can matches to 
the celt, representing extensive trade networks. The Coke 
can actually represents the global market economy, and the 
celt tells the story of Musqueam’s history of trade. Ancient 
Musqueam people, too, had far-reaching trade routes that 
enabled them to acquire resources—like the nephrite 
from which this celt was crafted—that were unavailable in the 
region. 

cyoh̓las (Having stories) 
When visitors touch Having Stories, a progress bar (specific 
to that belonging) appears to show how much more of 
the belonging they need to explore before they can unlock 
the video, encouraging them to spend more time with the 
information [DG5]. Once a visitor successfully completes 
the interactions for the first three categories, the progress 
bar becomes a button, allowing them to play a video clip 
with a Musqueam community member sharing his or her 
own personal narrative relating how they learned certain 
aspects of Musqueam culture and knowledge, relating 
intangible cultural knowledge to belongings. 

USER STUDY 
We conducted a field study of our ʔələwâk’st — Belongings in 
the gallery space at MOA to address our research question: 
What are effective design strategies that enable visitors to 
directly experience cultural values while they interact with 
Indigenous knowledge using a tangible tabletop system? 
The study consisted of observations and open interviews 
with 24 visitors. Two researchers conducted this study in 
the gallery space over the course of two weeks. We 
collected data for 11 men and 13 women ranging in age 
from 18 to over 50 years old.
Researchers observed visitors interacting with the table. When a visitor had spent at least 2 minutes with the table and successfully put a belonging in a ring to access What is this?, a researcher would ask them to participate. We settled on this time and interaction milestone method of visitor selection as the one with the least bias. We drew from Block et al.’s study [8] on fluid grouping at tabletop exhibits, excluding those who the researchers characterized as Shoppers and Joiners. If the visitor agreed to participate, the researcher would step aside as they continued their selection as the one with the least bias. We drew from this time and interaction milestone method of visitor selection as the one with the least bias. We drew from Block et al.’s study [8] on fluid grouping at tabletop exhibits, excluding those who the researchers characterized as Shoppers and Joiners. If the visitor agreed to participate, the researcher would step aside as they continued their exploration of the table. When visitors had finished using the tabletop, they filled out a brief questionnaire with demographic information and completed a structured interview lasting 10-20 minutes.

Data Collection
Our observational notes provide evidence that addresses how visitors entered the space and began interaction [DG1]. We designed our interview questions to explore visitor experience related to our other design goals [DG2-5]. We asked about visitor experiences in order of the goals (from entering/engaging to basic learning to deeper learning and the experience of values).

We began the interview with questions on what visitors learned about Musqueam culture and how they learned this (e.g. What was something that surprised you about Musqueam culture that you didn’t know before?) [DG2].

To gauge visitors’ understanding of the belongings and their stories [DG3&4], we asked questions about what they thought the objects represented, why they thought we called them belongings and if they saw any relationships between the four categories on information for each belonging (e.g. While using the table, you placed different objects in the ring. What do you think those objects represent?).

We asked visitors questions about what they learned of the Musqueam people [DG5] (e.g. Can you describe what you learned about Musqueam values that you didn’t know before? How did you learn this?). We followed up by explicitly telling them that one Musqueam value is that culture knowledge should be treated with respect and then asked visitors to describe if/how they might have experienced that with the tabletop. We also asked if there were any other values that might have been reflected in what they were doing with the belongings on the table. We followed up by explicitly mentioning each value and asking visitors to describe if/how they might have experienced that with the tabletop (e.g. A central Musqueam value is that cultural knowledge should be treated with respect. Can you describe any ways you might have experienced this value in the exhibit by what you did?).

Analysis
Interviews were audio-recorded and transcribed. In our analysis we looked at data from each interview question separately. In order to address the interdependent nature of our design goals we also looked across data sources to explore how our inter-related strategies impacted visitor experience. Three researchers individually analyzed the transcriptions using open coding to identify emergent themes. The researchers individually went through two passes of the interview transcripts alongside observational notes. In the first pass we each identified themes, in particular looking for themes that related design features with visitor responses or behaviours. We looked for themes that were common, interesting, unexpected or indicated problems with the design. In the second pass we each fine-tuned our description of the themes and looked for inter-relationships between them. Then the three researchers worked as a group and compared themes. We had inter-rater agreement on all themes except one, for which we discovered we had used different terms to describe the same elements. While this level of coherence was unexpected, it gave us confidence in the reliability of our coding.

RESULTS
Our analysis provides evidence for validation of our approach of using inter-related goals and design strategies to enable museum visitors to experience Musqueam cultural values through interaction, and highlights areas where we need further refinement or exploration.

While acknowledging that our consent protocol influenced the time spent with the table, our participants interacted with the table for at least 4 minutes, with an average of 8.8 minutes and a median of 6.5 minutes. One participant spent 40 minutes using the table. Participants overall enjoyed the experience and left with new information about Musqueam culture.

We also note that while our participants logged a total of 212 minutes with the tabletop, no one was able to access a video by exploring all four categories of information. User interface issues were a factor here, and we addressed these issues in a software upgrade (which is not reported in this paper), drawing on insights from this user study.

Engaging and Learning about Musqueam Culture
We found that three design features contributed to achieving our goals that people would enter the space, interact with the table, and learn something new about Musqueam culture. The visually interesting salmon cutting slide show and the fish cutting image on the tabletop were successful in attracting people into the space and conveying basic information about Musqueam life. The cart of physical belongings also drew people in and immediately informed them visually about the culture due to their display in this particular exhibit context as well as the inclusion of both ancient and modern belongings. All participants understood that the Musqueam people were a fishing society in the past, and that they still live in Vancouver today and carry on the fishing tradition of their ancestors.

“I learned that obviously fish is a big part of it, or else that whole graphic wouldn't be there, and they're using nets...
They have to pay attention to the tides when they're fishing.” – P22

The combination of the monitors along with the instructions, the rings, and the belongings—specifically the Coke can—all worked towards enticing people to interact. People picked up the belongings and rings from the cart and placed them on the table with little more than an illustration. The Coke can was a particularly interesting belonging that caught the eye of many participants. It motivated them to interact with the other belongings. Thirteen participants commented on this explicitly.

“I put the Coke bottle in there I just laughed at the description of it. It seems like just lacking of culture subject to all of our modern marketing and immediacy of our consumerism and all of that.” – P16

Similarly, the combination of the belongings, the ring tool, and the What is this? information cards worked as an entry point to interacting with the table. Although What is this? was an entry into the complex information available, this activity was valuable in itself as it gave basic information about the belongings that people might not be familiar with.

“I spent most of the time exploring What is it? rather than stories.” – P17

People learned new things about Musqueam’s fishing culture and the tools they used. Seventeen participants were able to explicitly describe a new piece of information about Musqueam culture that they accurately learned. They did this through their interactions with the ring, which enabled them to access information cards, as well as through directly handling belongings as physical forms. One participant described seeing a harpoon in a display case elsewhere, but actually learning more about it from interacting with it on the tabletop.

“I’ve seen those, it’s the harpoon? I’ve seen those in a couple display cases on my way here, and never knew what it was and what it would be used for, so it was kind of interesting to see what that was about.” – P03

Richness and Stories about Belongings

Our second two design goals were about visitors reaching deeper understandings: the richness of information represented by belongings (beyond the identity and simple function) and the complex stories related to belongings. We found that three design features helped us to achieve these goals. These features were the selection of both ancient and modern belongings, the fidelity of the replicas, and the complexity of the four inter-related activities.

Ancient and modern belongings

Thirteen participants expressed that they understood the continuity of Musqueam culture in their interview responses, referencing the history of Musqueam people and their community today. The design feature of using ancient belongings with contemporary items worked well to get people thinking about cultural continuity.

“They’re a changing culture. It’s sort of something I gleaned just by looking at the objects on the table in the first place. When you approach it and you see a harpoon and a Coke can together, you almost don’t need the table.” – P22

“This goes back again to the idea of the old object and the new object co-existing, in the sense that there’s hardly ever a distinct line between “Oh, this is the culture before, there’s the culture now.” – P18

The belongings, although they were physical objects, also represented intangible elements such as the complexity of their stories. As one participant expressed it, “Obviously Coca-Cola is not just Coca-cola.” – P11

Three participants overlooked the modern items, choosing to focus on the unfamiliar belongings. Their curiosity was satisfied by discovering what the ancient belongings were and what they were used for simply by accessing What is this? However, they missed some of the rich stories about the modern objects, and because they did not pair ancient and modern belongings, they missed learning about how traditions had evolved or remained the same (Teachings).

“I didn’t end up putting anything like the Coke can or the keys in there, I put all the little things that I didn’t know what they were for on the table.” – P03

Belonging Physical Fidelity

The fidelity of the belongings, our careful considerations of how realistic they should look and feel, and the choice of displaying everyday belongings were important in having visitors understand that they were of utility and value. Eight participants described the importance of the ability to handle the belongings and how it allowed for a better understanding of them.

“It was just nice to have something in your hand. It gives you a little bit better perspective in maybe how it was used and how in relation to the other objects and giving you a little more perspective in that way.” – P16

“I was using a knife… I kind of felt like the modern day knife, what we’re used to now, is very different than what they had, but that’s what they had. It’s what they were using, and it’s easy to understand how these tools were used and how these tools were created.” – P04

The fidelity of the belongings also affected other aspects of interaction and impressions about values, which we will discuss in the Values section below.

Activity Complexity

The belongings and physical-digital ring were designed to enable visitors to trigger four different activities, each with a different kind of information about the belongings. Participants clearly understood that there was more information available about the objects, even if they could not understand how to interact with all four categories. For example, our design decision to place duo-language labels
of the four categories of information on the ring tool enabled visitors to realize there was more information available. As one participant explained,

“It seemed almost like an intricate web. On the onset, it seems like they’re four separate things that you kind of click on, and then after while you play around with it a little bit, and you start realizing that no, they’re all connected. In order to fully understand it, you have to spend a considerable amount of time and mental effort to actually go through each of these little links and each of these little webs to actually get to that full understanding of how they’re connected.” – P18

The Understanding it task of matching belongings to the underlying image was effective in getting people to think about the continuity of culture as well as context. Visitors found that the ancient tools such as the slate blade and celt had more obvious connections to their modern day versions: the knife and the axe. By using some recognizable ancient tools and pairing them with modern counterparts, we enabled many visitors to understand the continuous and long history of Musqueam culture.

“Because the background was the modern objects, so to connect what is the possession of the belonging and how does it connect to a modern object that is still used today.”

Our decision to have belongings used on a tabletop display of a fish-cutting table provided context for the belongings. This decision enabled visitors to visually understand that the belongings and their stories related to one another, the belongings were embedded in complex stories [DG4] and the belongings showed how the Musqueam live today. For example, one visitor said,

“It’s to give the object a place in the context so it isn’t just an object in isolation. It’s an object that connects to other objects, like the people, other functions. It has a functional reason for being there. It doesn’t exist in isolation. It exists in context so it’s trying to give context.” – P06

“It’s good to know what something does, but there’s so much more to it than just what it does and what’s involved in actually using it... how long it takes to do things and there’re other pieces involved in using it and the engineering that goes behind it. There’s so much more involved than just what it is. It adds another dimension to the object.” – P16

The Teachings category, even though fewer people successfully accomplished that activity, still aided in achieving DG4 by showing the richness and complexity of information.

“(Matching ancient belongings to ancient belongings) would be important to understand how they’re still used the same way and how those uses have changed. That would be important. How perhaps we’ve left behind some of the ancient uses or we rely on newer ways of learning in ... new contemporary ways of fishing.” – P19

The four categories together on the ring, along with the status bar aided visitors’ understanding that there was more to the story. When asked the relationship among the four categories, participants responded,

“Sort of different levels of depth to the conversation, right, so one was just a description of the object or belonging and then an application of it, how it was used and then how it connected to something else.” – P17

“It seems like something can be a tool, but there’s something deeper behind it. It gives a little bit more layers to the piece and it makes it less of just an object. It gives you a little bit more insight into the culture and pieces together.” – P16

Values

The values we focused on were: treating cultural knowledge with respect, the importance of the hanq̓íqu̓im̓əm̓ language, the notion that belongings still belonged to the ancestors, and that cultural knowledge should be earned. Without meeting our first four goals, it seems unlikely visitors would experience values through interactions. Once visitors entered the space, interacted with different objects, learned about Musqueam people, and began to see the complexity of information available [DG1–4], they were cued to experience values. We found that these interrelated design strategies enabled visitors to experience values.

For example, we purposefully broke the tradition of displaying belongings behind glass, placing replicas on a museum cart (See Figure 2) where they would normally only be accessible to museum staff. Seven participants noticed respect reflected in the way they carefully handled and returned the belongings to their proper places. Even the contemporary belongings were treated with some reverence, due to social cues as some participants noted.

“I knew that I needed to put (the belongings) back where I found them in order to leave it for someone else to be able to follow me and do the table. In that way, that’s teaching me to be respectful for the display itself.” – P05

“I treated them carefully. Actually the Coke can you treat it a bit like a cultural artifact, but I think that’s because of the... social rules.” – P06

Figure 2. Belongings cart ©Reese Muntean
We also identified the physical-digital activity categories using both the hən̓q̓əmin̓əm̓ language and English, which created depth of content through non-linear layers (rather than linear game levels) and showed progress each time a belonging was placed in a ring. People were able to recognize values in their interactions, specifically in terms of the time and effort spent with the table.

Participants engaged with the table for an average of almost nine minutes, which illustrates the success of our choice to create complex interaction possibilities with inter-related activities and twelve different tangible belongings to use. Many visitors recognized that spending time to learn about this information was a way of respecting Musqueam culture.

="By taking the time to look at it... I’ll walk up and actually read more of what I’m looking on other than just looking at something. Definitely, taking the time to digest what I read and think about it from a different person’s place.” – P08

="I think in that way it’s giving your undivided attention as a way of showing respect.” – P15

="This is interesting. It’s subtle, but the value is having the respect to stay with something no matter what the situation is. My respect would have gone longer if it was a human. My respect was shorter because it was technology. That reflects on culture. If it is a human passing down traditions, it is longer term than to go back and just put out a book and try to teach it from a book. That’s a huge lesson that I surreptitiously got, but no one spelled it out for me.” – P21

The tabletop was a complex system, and people did not necessarily discover its full functionality. However, they did understand that making the effort was a sign of respect and earning knowledge.

DISCUSSION

In this paper we ask “What are effective design strategies that enable visitors to directly experience cultural values while they interact with Indigenous knowledge using a tangible tabletop system?” Yet key aspects of our collaborative approach extend beyond the tangible tabletop form. Our design process involved the close collaboration among team members with varying values and perspectives and our cultural partners. Through this collaboration we developed our goals for this project, including the desire to communicate values through interactions, the values that would be communicated, and the design strategies to meet these goals in a cultural tabletop exhibit by moving from basic engagement to deeper learning, then to the experience of cultural values.

From this process we introduce six recommendations for such designs. We generalize our findings so that other designers of technology for cultural heritage can support visitors in their experience of cultural values, through tangible interactions or interactions more broadly. We reiterate that these design recommendations exist within the context of collaboration with Indigenous partners in the design process and reflection on cultural values throughout.

Design Recommendations

1. Cultural Forms. Use both physical forms and the social practices around the forms to reflect values. Unusual or intriguing representations of cultural forms can draw people in. For example, the unusual images of fish and the high fidelity of the physical belonging replicas brought people into the space and enticed them to interact with the table, supporting Hornbeck’s concept of access points and entry points [37] and Horn’s cultural forms [34]. Furthermore, the design of the physical properties can highlight values. In the case of the production of the belonging replicas, great care was taken to create replicas that shared the look and feel of the originals. These replicas took weeks to make, highlighting that ancient belongings were hand crafted and important. Social practices can also guide interaction and communicate tangible and intangible knowledge, such as values. Interaction design can mimic, mirror or reverse such practices. We played on traditional museum storage practices and in doing so both utilized and broke social practices around (not) handling artifacts in ways that enabled visitors to experience respect for the objects.

We do see a missed opportunity in this work to connect the social practices of the ancient belongings back to the physical cultural forms of the replicas. For example, we imagine visitors moving the slate blade in a cutting action as part of their interactions with the system.

2. Accessible Information. Create opportunities for immediate interaction and access to basic information. Placing a belonging in a ring marked with hən̓q̓əmin̓əm̓ provides a very simple form of access allowing visitors to interact immediately, quickly learn basic information, and gain exposure to the value of language. Furthermore, obtaining the basic What is This? information was simple, in line with the idea of apprehendability [4], offering the early successes [2, 15, 23], encouraging visitors to continue, priming them to understand more complex concepts [14], and offering multiple layers of information [35].

We designed for access, as others have recommended, yet we also designed deeper layers of information that required time and effort to access, reflecting values of earning knowledge and treating cultural knowledge with respect. We ensured access, but the structure and activities of how further information was accessed reflected a cultural value.

The complexity of the system along with our decisions to give little instruction or feedback were intended to slow visitors down to take time with the information. This did work, yet we were hoping visitors would be able to access more content than they actually did. While some visitors did uncover the multiple layers of information available from the different categories, which can enable richer interactive experiences [15, 23, 35], most did not reach this level of understanding.
For Understanding it, many participants understood from the dotted line what they were supposed to do but were still unable to do so. This was a combination of technical issues (e.g. accidental touches changing the category on the digital ring) as well as interaction design issues leaving participants confused about how to complete the task. For Teachings, visitors were uncertain as to what they should do or assumed the table was malfunctioning. These activities need clear instructions on the table or salient feedback to help visitors access the information. In our post-study revisions to the system, we improved usability of the Teachings and Understanding it activities, which may enable more visitors to reach the Having Stories content.

While we do see these issues of instruction and feedback as an area in which we can improve the design, it also speaks to the success of the interactions in helping visitors understand the complex stories and values we wanted to convey. Tqewik' — Belongings is rich with content that tells specific stories about the belongings of the Musqueam people and their continuing culture, but visitors were able to grasp information about Musqueam culture and identity, complex meanings behind the ancient and contemporary belongings, and even the specific value of earning and respecting knowledge without actually accessing much of the content.

3. Connect. Connect the exhibit to visitors’ lives. The contemporary belongings provide connections from the exhibition to visitors’ personal worlds. This provides a comparative foundation that may encourage visitors to connect cultural values to their own values. The juxtaposition of ancient and contemporary belongings encouraged visitors to think about the combination of objects, mentally engaging with the belongings before even physically interacting with them.

4. Contextualize. Provide context through different modalities. We found that, as suggested by Giaccardi and Palen [25], the multimodal information and the multimodal forms of interaction aided the exploration of tangible and intangible cultural heritage and allowed for new ways of engaging with specific cultural values. The tabletop fish cutting table image, the belongings, and the hatchamumun language on the rings provided immediate context for visitors (before ever accessing the informational content). Visual and physical elements of our design immediately convey the strong fishing tradition of the Musqueam. The pairing of modern and ancient belongings creates a contextual timeline, connecting past and present.

5. Hands on values. Design the physical properties of tangible objects to convey cultural values in such a way that visitors can immediately perceive those values as they view and handle the objects. Visitors viewed and carefully handled lifelike replicas of belongings, and then placed them back in their marked location on the cart. Because of the replicas’ high-fidelity form and their presentation, visitors directly experienced reverence and respect for these belongings, and by extension for the culture. There are many possibilities for reflecting values in physical forms. For example, the value of recycling could be communicated by low-fidelity, easily decomposable forms.

6. Non-linear explorations. Allow for different pathways for exploring information. We used four non-linear but inter-related activities that enabled visitors to engage with belongings in a variety of different ways, all of which conveyed complexity of information and reflected values without forcing visitors to explore all content. In other tabletop designs, tangible objects often trigger only simple pieces of information (e.g. [35]) or have single-use functions (e.g. magnifying glass). We suggest that a single belonging can enable a series of interrelated non-linear activities, providing a rich interactional experience. Individually these non-linear activities can appeal to visitors in different ways, with some people preferring basic information and others enjoying more puzzle-like activities. Taken together, these activities help to convey complex information and can be used to embody cultural values. While visitors could explore as much or little of the content they liked, the number of belongings and the ring’s belonging-specific status bar hinted at the depth of information available and conveyed values around taking time, care, and effort to understand Musqueam culture. The specifics of activity designs will necessarily change based on the cultures, values, and exhibitions -- providing rich opportunities for new research.

CONCLUSION

In this paper we explore how cultural values can be communicated through interactions with a digital system, illustrating how values can be made tangible through a collaborative design approach to an interactive tangible tabletop museum exhibit. We see that experiencing cultural values through interactions is possible as a result of a collaborative process with a careful consideration of cultural values, physical and digital content design that lays a foundation for conveying values, and value-sensitive interaction design. We describe how we communicated cultural values by embodying them in tangible objects, playing on social practices, embedding them in activities that together with digital content creating opportunities for visitors to experience values through their interactions. We offer six design recommendations that may benefit designers of other culturally specific heritage applications and exhibits.

We found that tangible and embodied forms of interactions can be effectively used to support a greater understanding of values, Indigenous heritage, and continuity of culture in a museum setting. Overall, we hope our process and design can further the discourse around technology and values. We see our work as a successful contribution in understanding how to engage with cultural values during the design process and how to ensure that values are communicated through interactions with the resulting system.
ACKNOWLEDGEMENTS

Special thanks to the Musqueam Indian Band, Museum of Anthropology at the University of British Columbia, Maia Jensen at the SIAT Solid Space Fabrication Lab, SSHRC, and Grand NCE.

REFERENCES


Appendix B.

Abstract
Our pictorial visually describes ʔeləw̓kʷ — Belongings, an interactive tangible tabletop installed in the Museum of Anthropology at the University of British Columbia. The tabletop was designed to communicate the continuity of Musqueam culture, convey the complexity of belongings that were excavated from Musqueam’s ancient village site, and reconnect those belongings to traditional practices and oral histories through tangible interactions with the table—all while highlighting that cultural knowledge should be treated with respect. In this pictorial, we will show how the design process was shared among researchers, curators, and the exhibit Advisory Committee and highlight some of the key design decisions that came out of this collaboration.

Authors Keywords
Tangible interaction; intangible cultural heritage; digital heritage; Museum of Anthropology; Musqueam Indian Band; ʔesnəʔəm.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces, Evaluation/Methodology.
Introduction

ʔeləw̓kʷ — Belongings is an interactive tangible table at the Museum of Anthropology (MOA) at the University of British Columbia in Vancouver, Canada and was developed for the čəsnaʔəm, the city before the city exhibition. The exhibition is a partnership among the Musqueam Indian Band, the Museum of Vancouver, and MOA along with the University of Waterloo. In three unique but related exhibitions, the institutions introduce visitors to čəsnaʔəm, an ancient Musqueam village and cemetery near the Fraser River on which part of modern day Vancouver was built.

Using replicas of ancient belongings excavated from čəsnaʔəm and everyday objects in contemporary Musqueam lives, the table shares stories of the Musqueam community’s past and how their culture and traditional knowledge continue today. In this pictorial, we will show how the design process was shared among researchers, curators, and the exhibit Advisory Committee and highlight some of the key design decisions that came out of this collaboration.
Speaking of Belongings

Archaeologists generally refer to the material culture they excavate as “artifacts”. Our Musqueam collaborators understand these items to have been created by, and to continue to belong to, their ancestors. For this reason we refer to them as ʔəwəmł̓kw̓ʷ, a hən̓q̓əməm əm term meaning belongings. By reframing Musqueam’s material culture using this term, we emphasize the continuity of intangible forms of knowledge that are intrinsically connected to belongings.

Relationships and Networking

Today, museums are building new relationships with contemporary Indigenous peoples. This includes repatriating belongings and ancestral remains that were dispersed in collections around the world during a period following the implementation of the Indian Act (1884) in which the Indigenous populations were at their lowest ebb [7]. Museums are also struggling to find ways to represent intangible cultural heritage in the museum space [4]. The development of the ʔəwəmł̓kw̓ʷ — Belongings tabletop exhibit has roots in a paradigm shift in North American museology focused on building new relationships with First Peoples [1] and addressing these challenges of showcasing and safeguarding intangible cultural heritage [11].

One of the reasons we were even able to produce this work is the continuing relationship between the Musqueam Indian Band and MOA. Particularly successful in laying the groundwork for ʔəwəmł̓kw̓ʷ — Belongings was the collaborative effort among Musqueam, the Stó:lō Nation, the U’mista Cultural Society, and MOA to create the online portal known as the Reciprocal Research Network (RRN), which makes dispersed collections of ancient belongings accessible digitally to communities and researchers [8, 9]. The thumbnail photos below show some of the belongings excavated from čəsnaʔəm that are in the Laboratory of Archaeology, housed at MOA, accessed through the RRN during the ʔəwəmł̓kw̓ʷ — Belongings design process, and incorporated into the final tabletop installation.

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Development Process and Goals

Susan Rowley, Jordan Wilson, and Lisa Uyeda at MOA worked with Kate Hennessy, Alissa Antle, Rachael Eckersley, Perry Tan, Brendan Matkin, and Reese Muntean at Simon Fraser University’s School of Interactive Arts and Technology (SIAT) to develop the tabletop application. With a tight deadline and only five months to complete the project, we immediately scheduled weekly two-hour in person meetings. The meetings were initially used for brainstorming, activity design, and presenting ideas and work. Outside of these meetings Rowley and Wilson would gather and organize the content for the table (e.g. historical images, quotes from Musqueam community, information about fishing) and check in with the elders on the Advisory Committee regarding our progress. SIAT students would hold additional meetings during the week to design the visuals, graphics, and interactions, as well as write the code. During the first meeting, we outlined a number of goals for the tabletop. In this pictorial we will touch on some of the decisions we made to achieve our goals of helping visitors understand the complex stories connected to belongings and communicating Musqueam values and cultural knowledge.
Once we had the basic idea for a tangible tabletop and knowing that we had certain goals in mind to tell the story of Musqueam identity and culture, we needed an activity and focus to bring this all together. We landed on salmon fishing. Many of the ancient belongings from cəsnaʔəm were related to fishing, an activity that is still an important part of life today. We were inspired by the fish cutting table of Sonny Williams of the Scowlitz First Nation—shown here—which was photographed as part of a project that Hennessy and Muntean were working on up the Fraser River with the Stó:lō Nation.
Processing Fish
We saw a wonderful opportunity to show the continuity of Musqueam’s own fishing culture and values and how these traditions continue today. Wilson and Muntean teamed up with the Musqueam Fisheries Commission to photograph the process of cutting and cleaning salmon outside of the community smokehouse for the main image on the digital table.

* Photo © Jordan Wilson
Final Fish-Cutting Image

Here is the image that appears on the ʔeləwíkʷ—Belongings table. Using a top-down view, visitors are able to place themselves in the scene cutting fish, surrounded by related tools and items, making the image one of the present day.
Replicating Belongings

As we came up with the concept of the interactive salmon cutting table, we also needed to select physical belongings that would interact with the table, incorporating ideas from tangible computing as well as museological discourse around objects themselves embodying knowledge. Indeed, we agreed that “a necessary condition for the generation of knowledge is engagement with objects” [10].

Rowley and Wilson selected the six ancient belongings that best tell the stories of Musqueam practices and continuity of culture. The Musqueam Indian Band gave permission for molds to be made of the original belongings. Replicas of belongings provided the opportunity for museum visitors to spend time with Musqueam belongings from cəsnaʔəm and to interact with them and handle them in a way that the exhibition of real belongings would not allow.

One of our key design decisions was to include both ancient and modern belongings as a way to show how common the ancient belongings were in day to day life and to get visitors thinking about their importance. Six modern belongings were also selected. The juxtaposition of the ancient and contemporary belongings were effective in that people would explore unfamiliar belongings while the modern belongings would encourage them to question how how they are all relevant to Musqueam culture [5, 6].
Interactions with Belongings

The final set of belongings includes six ancient (adz, slate blade, cedar bark, net weight, decorated piece, and harpoon) and six contemporary belongings (Coke can, ice cube, quarters, keys, status card, and tide chart). The physical interactions with these belongings and the digital tabletop helped visitors connect the histories of the belongings to one another as well as to present-day issues, showing just how complex these stories can be. The belongings serve as entry points and inputs for interacting with the tangible table. These belongings, along with activator rings, enable different sets of interactions to reveal layers of multi-modal information [2], evoking cultural forms [3] and revealing complex stories about each belonging’s place in Musqueam life and how the related practices have shifted and were sustained over time.
To reconnect the day-to-day cultural practices to belongings both ancient and modern, we focused on šəmələn (What is this?), tətaləm (Understanding it), snəwəɬ (Teachings since childhood), and cyəθəs (Having stories). These are the four categories etched into the activator rings and that appear in the digital ring interface. Using these concepts, we led visitors through a series of interactions to learn about belongings’ form and function (What is this?), connect belongings to the fish-cutting table image (Understanding it), match ancient belongings with modern personal items (Teachings), and ultimately unlock stories from Musqueam community members about the process of learning and their traditional culture (Having stories). An example of two of these belongings and their connections are detailed in a flowchart on the following page.
When you first place a belonging in one of the rings on the table, basic information appears on the table. Here, text and images appear explaining that the belonging is a Coke can or that it is a jadeite adz used for carving.

Each ancient belonging pairs to a modern belonging, and when visitors enter the teachings category they will be prompted to make that connection. The Coke can and adz pair in this way to tell the story of historic and contemporary trade routes.

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In the Understanding It category, visitors match a belonging to its corresponding area on the fish cutting table. The Coke can matches to the salmon fillets to access information about the changes in traditional diet brought about by issues including access, overfishing, and pollution.

When visitors connect the adz to the axe, its modern counterpart, they learn about how the adz was used, the long history of carving, and the importance in the community. Community members share their grandparent’s stories of building boats, and images and text show the structure of the long houses.

Once a visitor explores the first three categories of information, the monitor associated with the ring plays a video of a community member sharing stories about learning cultural practices and their own lived experiences.
**Conclusion**

The flowchart on the previous page aims to clarify how belongings connect to one another, to the underlying fish cutting image, and to the community voices that reveal the intangible heritage associated with them. These connections and interactions are made with each of the twelve belongings. It is a complex web of relationships, but this was also what we wanted to convey to visitors. In taking the time to interact with the tabletop and navigate these complexities, we are sharing with visitors the ideas of earning knowledge and that cultural knowledge should be treated with respect.

These belongings – the tangible interface – respond to the challenge of representing the significance of both archeological and everyday belongings in a museum space. The choice of ancient and modern belongings for the tangible interface further highlights cultural continuity and how ancient belongings connect to contemporary Musqueam life. While engaging with the belongings, visitors are engaging with Musqueam cultural knowledge, but also issues of access, preservation, and continuity of culture that are central to discussions of digital heritage.

* Photo ©Jordan Wilson
References


Photography

All photography ©Reese Muntean unless otherwise noted.

Acknowledgments

Special thanks to the Musqueam Indian Band, Museum of Anthropology at the University of British Columbia, Maia Jensen at the SIAT Solid Space Fabrication Lab, and Grand NCE.
Appendix C.

Study Materials

This appendix contains the materials used for the study described in Chapter 4. Those materials are:

1. Advisory Notice posted during the study
2. Consent Form
3. Questionnaire
4. Study Protocol
5. Interview Questions
6. Structured Observation Sheet
Please Be Advised:

There is currently a research study taking place in the Belongings exhibit.

You may be approached to do a short interview. It is completely voluntary. Feel free to say no if you are not interested.

You are welcome to approach the researchers (they are usually holding clipboards) with any questions, or if you’d like to take part in the study.

Thanks!
INFORMED CONSENT BY PARTICIPANTS IN A RESEARCH STUDY

Title: ʔeləkw̓ — Belongings
SFU Principal Investigator: Dr. Kate Hennessy
SFU Research Team Members: Dr. Alissa Antle, Brendan Matkin, Reese Muntean
UBC Principal Investigator: Dr. Susan Rowley
UBC Research Team Members: Jordan Wilson
Investigator Department: SFU School of Interactive Arts & Technology
Funding Agencies: SSHRC

Ethical Conduct
The University and those conducting this research study subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of participants. This form and the information it contains are given to you for your own protection and to ensure your full understanding of the procedures and benefits described below.

If you have any concerns or complaints about your rights as a research participant and/or your experiences while participating in this study, contact the Research Participant Complaint Line in the UBC Office of Research Services at or if long distance e-mail or call toll free .

Purpose and Goals of this Study
The activity in which you have been asked to participate in is part of a study of the design of the interactive tangible table in the əsənəʔam; the city before the city exhibition at the Museum of Anthropology at the University of British Columbia.

This research will contribute to future work in the development of new technologies that will allow museum visitors learn through exploration of tangible user interfaces and digital tabletops or the development of new activities and applications for such technology. The work produced from this research will appear in public documents including graduate student thesis work, published academic research papers, and/or presentations at academic conferences.

What Participants will be Asked to Do
After you have interacted with the digital tabletop portion of the əsənəʔam; the city before the city exhibition, you will be asked some questions and may be asked to fill in a questionnaire about the experience. The study will take place in the Museum of Anthropology at the University of British Columbia.
Potential Risks
Risks encountered through participation in this study are the same as in every day life; there are no expected risks associated with participation.

Use of Participant Data and Study Results
The data gathered in this study will be used to understand more about how to design digital tabletop games for learning for children and adults. We will audio record interviews and/or photograph some portions of the session so that we will have this information for later use and can focus on working with you in the session. The results from this study, including audio transcriptions or photographs that may be used for illustrative purposes, may be shared with the faculty and graduate students at Simon Fraser University. It may also be included in graduate student thesis work, published academic research papers, and presented at academic conferences.

Confidentiality
Personally identifiable information such as your first and last name will never be used to refer to you under any circumstances. All questionnaires as well as audio, photography, and transcription files will be indexed by session and not labeled with participant information. To highlight key findings from our work, we may include one or more photographs of the study in a published thesis, journal, conference paper, presentation, or promotional video. If you agree to appear in photographs, please check the box below. All study data will be kept as digital files on an encrypted removable hard drive in a locked cabinet in the PI's locked research lab for a minimum of two years. After five years unused data will be destroyed.

Voluntary Participation
Participation is voluntary, and you may withdraw at any time. Any data collected will be destroyed if you withdraw.

Contact
If you have any questions about this study or you would like to obtain copies of the results of this study, you can do so by contacting the principal investigator named above.

Consent
Your signature on this form indicates that you have received this document outlining the possible risks, benefits, and procedures of this research study, that you have received an adequate opportunity to consider the information and ask questions, and that you agreed to participate in the study. If you are a member of a First Nation, your band has not given consent for your participation.

First and last name (print)  Phone and/or email Contact (optional)
☐ I agree to be interviewed.
☐ I agree to fill out a written questionnaire.
☐ I agree to appear in photographs in academic publications, presentations, or university promotions.

Signature  Date
Title: ʔeləw̓kʷ — Belongings
SFU Principal Investigator: Dr. Kate Hennessy (  )
SFU Research Team Members: Dr. Alissa Antle, Brendan Matkin, Reese Muntean
UBC Principal Investigator: Dr. Susan Rowley
UBC Research Team Members: Jordan Wilson
Investigator Department: SFU School of Interactive Arts & Technology
Funding Agencies: SSHRC

QUESTIONNAIRE

How old are you? < 18  19-29  30-50  51+

Gender: Male  Female  Other: __________

Job/Profession: ______________________________________

English Fluency (ILR):

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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<tr>
<td></td>
<td>No Proficiency</td>
<td>Elementary Proficiency</td>
<td>Limited Working Proficiency</td>
<td>Professional Working Proficiency</td>
<td>Native/Bilingual</td>
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</tbody>
</table>

Education:

None  Elementary  High School  Undergrad  Graduate  PhD  Trade

Where do you currently live? ____________  How long have you lived there? _______

Where did you live previously? _____________
STUDY DESIGN & PROTOCOL

Preparation

1. Clean table if needed
2. Power up, start TUIO server, start application (version: “Brendan’s Version” (csnmtt_0111_v003+))
3. Reset belongings on cart
4. Power up wall speakers and wall TVs
5. **Clipboards**: Protocol Script, structured observation form (v.1.1+), interview form (v.3.0+)
6. **Handouts**: Consent, Questionnaire
7. **Prepare audio recorder** (batteries, backup batteries, ?? clear ??, verify date and time).

Notes:

User ID (UID) format: - “XX##” e.g. “AA04” (add description if needed, i.e. “AA04 – blue jacket”)  
- increment the letter-pair each day (day two = BB##)  
- increment the number for each user  
Researcher ID (RID): - your initials, including middle name: e.g. BBM

Describe User (e.g. blue jacket, long hair, etc.) on observation sheet if needed.

All files for this study (Brendan Thesis) are named “Belongings___...v.#.#.pdf“. If the files contains TT or TEI or CHI, you have the wrong file!

Remember to BE NEUTRAL:
- “Tell me more about that.”
- “Anything else you would like to add?”
- “Thank you”
- “That was helpful”
- Use the pre-determined prompts if necessary.

Avoid:
- “Good/Bad”
- Improvising/modifying the script.
### Protocol: 20 minutes (+ 0 to 30 min use time)

<table>
<thead>
<tr>
<th>Duration</th>
<th>Activity</th>
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| **(0 min)** | *Table reset (if no users are present)*  
[clear user progress - force timeouts by placing new belongings in rings]  
[reset belongings on cart]  
[fresh interview forms & observation notes] |
| **(0-30+ min)** | *Observe Users*  
[fill out observation form (v1.1+). Start time = when belonging placed in ring]  
[exclude users < 2 min, exclude users who don’t enter UI, T, or HS]  
(< 2 min = intruders & shoppers) (Block et al., 2015) |
| **(1 min)** | *Introduction & Approach*  
Hello, my name is _____, (and this is ______). We are doing a research study that involves asking people about their experience with this exhibit. May I/we ask you a few questions? It will take 10-20 minutes.  
[Yes] - Thanks! Let’s go sit over here.   
[No] - No problem, thanks anyway! Enjoy the exhibit! |
| **(3 min)** | *Consent*  
Before we get started, could you please read this consent form? Sign here if you agree.  
[No/Do not agree] - No problem! Thanks anyway; we hope you enjoyed the exhibit. |
| **(2 min)** | *Questionnaire*  
[start AUDIO]  
We’d like to collect some demographic information about everyone we interview, Would you mind filling out this short questionnaire? |
| **(10-20 min)** | *Interview (version 3.0+) & Observation Follow Up*  
[complete interview form] |
Wrap-up

Thanks again for helping us out! Do you have any questions?

[Yes] - [answer questions]

[No] - Ok.

Have a great day, and enjoy the rest of the exhibits!

End of DAY

[copy session logs to hard drive or thumb drive]

a. Close the application  
b. Navigate to xxxxxxxx (log location)  
c. COPY to External Drive/yyyy-mm-dd/logs/

[transfer audio files to hard drive or thumb drive]

a. Connect recorder to windows computer  
b. COPY files to External Drive/yyyy-mm-dd/audio/  
c. ?? clear recorder ??

[file consent forms, observation notes, interview forms into locked storage]
Thanks for taking the time to do this interview! All of these questions are only about the interactive table.

(3 min) RQ 1

1. Can you describe what you learned from the table about Musqueam culture that you didn’t know before?

2. What did you read, do, see, or hear to learn this? [can you be more specific about how you learned that?]

(5 min) RQ 2

3. Can you identify any Musqueam values that you learned about from interacting with the table? [what are some thing that are important to Musqueam people? What do they believe?]

4. What did you read, do, see, or hear to learn this? [can you be more specific about how you learned that?]

(3 min) RQ 3

5. What do you think the belongings represent? [Belongings are the objects you placed on the table]

6. The ancient objects are accurate replicas of actual Musqueam belongings. Did handling accurate replicas affect your understanding of Musqueam culture? If so, what did that teach you about Musqueam culture? [..what did using the belongings teach you..]

7. Did handling accurate replicas affect your understanding of what values are important in Musqueam culture? If so, what did that teach you about Musqueam values? [..what did using the belongings teach you..]
(3 min) RQ 4

8. Did using replicas to trigger a menu affect your understanding of what information was available about Musqueam culture? [How so? \ Why not? \ The 'menu' is the ring of buttons that appeared on the screen when you placed a belonging on the screen]

9. What, if anything, did that tell you about Musqueam values?

10. Did you notice any relationships between the four categories of information for each belonging? If so, what relationships did you notice? [How do you think were they related to each other?]

11. Why do you think you needed to match a belonging to a hotspot on the table?

12. Why do you think you needed to match an ancient and modern belonging?

13. Do you know what the Making Stories category does? Y / N
   a. Why do you think you needed to do the other activities before you could trigger a Making Stories video on the monitor?

14. A central Musqueam value is that cultural knowledge should be treated with respect. Can you describe any ways you might have experienced this value by what you did? [Were there any specific actions that helped you experience respect for cultural knowledge? \ ...not something you read.]

15. How do you think other values might have been reflected in what you did with belongings on the table? [You may have learned values by reading or seeing pictures, but what values were portrayed through actions using the physical objects (belongings/artifacts)?]
Belongings Structured Observation Sheet - v. 1.1

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