



WPI

Worcester Historical Museum: An Interactive Redesign of the Fuller Gallery

A student-based undertaking submitted in the form of an Interactive Qualifying Project at Worcester Polytechnic Institute.

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Abstract

The Worcester Historical Museum strives to educate all individuals invested in the history of Worcester, Massachusetts. The Worcester Historical Museum administration seeks to overhaul the Fuller Gallery, which contains *In Their Shirtsleeves*, an exhibit chronicling the rich industrial heritage of Worcester and its surrounding townships.

The first objective of the redesign was the creation of a new interactive design for David Clark Company's Full-Pressure Flying Suit. In addition, the museum staff seeks an interactive exhibit design that educates visitors about Worcester resident Joshua Stoddard's steam calliope. Finally, the administration seeks to incorporate a digitized version of Worcester city directories. The efforts of our team build upon those of previous Worcester Polytechnic Institute students.

Executive Summary

The Worcester Historical Museum (WHM), located at 30 Elm Street in Worcester, Massachusetts, is the sole authority on the history of Worcester and its inhabitants. Worcester has a rich and diverse history, with strong connections to important people and events in the course of American history. One of the most modern representatives of Worcester's role in American history is the David Clark Company, a pioneer in the creation of Full-Pressure High Altitude Flying Suits. These are the predecessors to the modern suits used by NASA for space and atmospheric exploration. This flying suit is one of the many artifacts that shaped Worcester's Industrial history which are currently exhibited in its Fuller Gallery, under the heading of the *In Their Shirtsleeves* industrial history exhibit.

Due to the immense amount of material contained within the gallery, the exhibit as a whole feels static and does not promote interactivity. The layout of *In Their Shirtsleeves* currently follows a timeline posted along the walls, starting with artifacts and data from the early 17th century and culminating with examples of modern industrial design from the early 1990's. During the process of providing an educational and memorable experience for visitors, an exhibit that lacks interactive exhibits will prove to be ineffective in creating the required visitor engagement.

The overarching goal of our project was to revitalize WHM's *In Their Shirtsleeves* exhibit through the use of interactivity and digital technology. Our team focused our efforts on several key objectives to accomplish the following goals:

- Develop a database that will allow museum staff and visitors to easily and effectively access the city directories of Worcester.

- Develop an interactive design for the David Clark Company's Full-Pressure High Altitude Flying suit exhibit, which integrates to other space related highlights of Worcester's industrial history such as Robert Goddard and modern rocketry.
- Develop an interactive design for the Joshua Stoddard steam calliope exhibit that incorporates digital simulation technology and sensory interactivity.

The Worcester Historical Museum staff, specifically Executive Director Mr. William Wallace and Exhibitions Coordinator Ms. Vanessa Bumpus, served as our project sponsors for the duration of this project. The museum staff and resources provided us with the necessary information and expertise for the completion of the project objectives.

Small museums like the Worcester Historical Museum have a unique ability to give each visitor a personalized and special experience (Lord, 2002). Each and every visitor can discern which parts of the museum they will explore and what order they go about viewing different exhibits. The museum is able to display much more in-depth information about specialized content and specific artifacts that a large scale museum cannot afford.

Small museums face many challenges. The most notable challenges include budget constraints and physical space limitations. Ultimately, exhibit coordinators and designers need to be aware of all limitations and restrictions during the process of designing an effective exhibit.

During the fall of 2012, WHM created the Alden Gallery to provide a dynamic and interactive environment for families that visit the museum (as shown in Figure 1 below). The Alden Gallery is an excellent representation of visitor engagement through interactive exhibit design. The gallery remains a favorite amongst local elementary schools and families. The WHM staff and board of directors intend to use the Alden Gallery as a guiding example for the continued implementation of interactive designs in the other galleries of the museum. The Fuller

Gallery, home of the *In Their Shirtsleeves* exhibit, is the current focus of WHM's interactive redesign process (as shown in its current state in Figure 2).



Figure 1: Snapshots of Alden Gallery (WHM, 2014)



Figure 2: Snapshots of Fuller Gallery (WHM, 2014)

Methodology

Our team chose to focus our redesign efforts around David Clark's Full-Pressure suit and Joshua Stoddard's steam calliope, as the museum determined that these items had the most potential for successful interactive redesigns within the entire exhibit. We inferred the flying suit would naturally capture the attention of museum visitors. Conversely, the Fuller Gallery only has one picture of the steam calliope; and we foresaw an opportunity to educate the visitors more about such a unique musical instrument.

Our tenure at WHM began with research and series of interviews regarding museums that successfully utilized interactive exhibit designs. Our visits to *Boston Children's Museum (BCM)*, *New York Historical Society (NYHS)*, and *The 9/11 Memorial and Museum* enabled us to observe interactive exhibits in context and to interview museum staff members involved in the engaging exhibit design process. Specifically, we interviewed Mrs. Marla Quinones, Director of Exhibit

Design and Production at BCM, and Mr. Chris Catanese, Director of Museum Administration at NYHS.

In order to effectively display a redesign of David Clark's Full-Pressure suit and Joshua Stoddard's steam calliope in the exhibit, we researched a variety of different exhibits that properly utilized as much interaction as possible. To create a database, we first identified the primary users of the database. Understanding the database users and their needs allowed us to identify an appropriate framework for the design process. Upon selecting a framework, we then researched potential methods for completely digitizing the city directories. Our team then spent a great deal of time evaluating the methods and resources necessary to successfully implement a search function within the digitized copies of the directories. After the creation of a fully functional prototype directory, the team devoted their efforts to applying a visually engaging format for the directory. The culmination of the team's efforts regarding the creation of a digital directory included a variety of testing and evaluation procedures.

Findings

After gathering all information from our research, the feedback from Worcester Historical Museum staff members, and our observations of the museum's exhibits, we inferred the *In Their Shirtsleeves* exhibit would benefit from interactive redesigns of the Full-Pressure suit, steam calliope, and the Worcester city directories. Upon reevaluation of the methods we utilized in the interactive redesign process of the *In Their Shirtsleeves* exhibit, we developed working interactive prototypes for each of the three artifacts. The following highlights an outline of the project team's findings.

Understanding Museum Visitors

The most common age groups visiting Worcester Historical Museum were students under 12 and adults over 30.

After interviews with WHM staff members and our observations of the different galleries, we realized that the interactive exhibit redesigns would have to appeal to different age groups.

Visitors retain more information about interactive exhibits than static exhibits.

Although all of the exhibits in the museum have labels and other documentation to inform guests, our observations of visitors in the Fuller and Alden galleries showed that visitors demonstrate a much deeper level of knowledge regarding the interactive exhibits of the Alden Gallery than they do in regards to the static exhibits of the Fuller Gallery.

Worcester City Directory Findings

An E-Book format for the digital city directories would be easier, more efficient, and more interactive than an Access database.

After interviews with Mrs. Robyn Conroy, Worcester Historical Museum's Librarian, and Ms. Diane Strong, a professor at Worcester Polytechnic Institute (WPI) specializing in database technology, we concluded that an electronic book (E-Book) format for the city directories would prove most effective. While traditional databases are best formatted for storing large amounts of information, E-Books allow for more interactivity and are much simpler to use.

The most efficient way to convert a physical directory to a digital format is to chop and scan the directory using a sheet-fed scanner.

After an interview with Ms. Jessica Colati, the Assistant Director for Curation, Preservation, and Archives at WPI, and evaluating different scanning methods, we found that chopping and sheet-feed scanning the directories is the most time and cost efficient strategy. The only caveat is ensuring that the physical directories have duplicates before chopping and scanning them.

The optical character recognition (OCR) software featured in Adobe Acrobat is efficient for the search option presented in the digital directory.

After discussing different OCR software with Ms. Jessica Colati, researching all of the different possibilities, and testing the prototype with visitors, we realized that the OCR feature in Adobe Acrobat is effective and cost efficient. This software suite is easy to use for system-users and does not require any specialized skillset to utilize.

Visitors with genealogical ties to the city directories display a much deeper level of engagement with the directory terminal.

During the testing phase of the project, many museum visitors approached the directory terminal and expressed interest in the directories. Visitors with a genealogical connection to the directories (often a family member that lived in Worcester during the given time period) conveyed a much more enthusiastic response to the prototype. Visitors that searched the directory for specific names had a much greater linger time than other visitors and asked about more detailed questions about the features and capabilities of the prototype.

The Full-Pressure suit redesign helps to educate visitors about the connection that Worcester shares with the history of American space exploration.

After an interview with Bill Wallace and Vanessa Bumpus, we agreed that the Full-Pressure suit redesign would provide the visitor an explanation of why human space travel would not be possible without Worcester. Visitors would interpret the story of the David Clark Company's role in providing the National Aviation and Space Association (NASA) with pressurized suits to use in space exploration missions.

The design criteria for the Full-Pressure suit included incorporating some technology and providing rewards for younger visitors.

After interviews with WHM staff members, Boston Children's Museum's Marla Quinones, and Higgins Armory curator Jeffrey Forgeng, we developed the design criteria for the Full-Pressure suit. This involved using technology to both engage and educate visitors.

Trying on various components of a replica Full-Pressure suit was infeasible.

After discussing the possibility of visitors trying on various parts of a replica suit (gloves, helmet, etc.) with Marla Quinones and Vanessa Bumpus, our team determined that this would raise sanitation concerns. Vanessa Bumpus stated that the frequency with which the museum would need to sanitize the equipment would prove too time consuming and expensive.

Utilizing green screen technology/Chroma key software satisfies both the learning outcomes and design criteria.

After visiting the Boston Children’s Museum and American Museum of National History and conducting extensive research, we came to the conclusion that utilizing a green screen for the Full-Pressure suit redesign would be both interactive and educational. We found that other museums such as AMNH utilize green screens for attraction purposes and that *VidStudio* is an effective and no-cost solution for live feed Chroma key software.

Younger visitors enjoy role-playing with the live feed green screen software while older visitors enjoy getting a picture taken.

After testing the green screen prototype, we realized that the green screen has different outcomes with different visitors. Younger visitors exhibited the most enthusiasm and interaction with the green screen, showing a strong interest in the live feed displayed on the video monitor. Older visitors, particularly those over the age of 25, conveyed a desire to save an image of their photograph imposed upon a Chroma key background.

Steam Calliope Findings

The interactive redesign of the exhibit containing Joshua Stoddard’s steam calliope should educate visitors about the steam calliope and its connection to Worcester’s history.

After an interview with Bill Wallace and Vanessa Bumpus of WHM, the project team developed several learning outcomes for the visitors in order to enjoy an interactive music exhibit featuring Stoddard’s steam calliope.

Our design of the steam calliope exhibit should address any challenges that an interactive exhibit would confront.

After visiting the Boston Children’s Museum and interviews with WHM staff members, Mr. Jeffrey Forgeng and WPI music professor Mr. Victor Manzo, we came to the conclusion that the design criteria for the calliope redesign must cover a wide range of ideas, including the volume level, sanitation of the device, and durability, among a few others.

A software application run on a touchscreen device successfully addressed the ‘hands-on’ experience aspects we desired, such as virtual buttons or a virtual piano-style keyboard.

After extensive research and discussions with Seven Hills Charter school teacher Ms. Kathy Holton and *Steamboat Natchez* calliope performer Ms. Debbie Fagnano, we were able to create and test a playable keyboard through a mobile application run on an *iPad*.

Museum visitors displayed significant interest in the calliope keyboard.

After testing the calliope keyboard application with visitors, we found that the visitors enjoy the app and are able to play simple songs such as *Hot Cross Buns* and *Twinkle, Twinkle Little Star* when provided with simple sheet music which is easy to follow and requires no musical background.

Visitor interaction with the calliope keyboard varies with age.

After testing the calliope keyboard with visitors from ages 5 to 75, our team inferred a small difference in visitor engagement with the device. All visitors that tested the calliope keyboard had minimal or no musical experience, but younger visitors, specifically children under

the age of 15, expressed interest in hearing the sound of each note on the keyboard. Visitors over the age of 15 verbally expressed a desire to hear full compositions of traditional calliope songs.

Recommendations

The result of our project was a solid framework of new steps taken to redesign a part of the *In Their Shirtsleeves* collection. These steps show the methods we conducted in order to achieve our project objectives. We have a list of recommendations for WHM to consider in order to continue the redesign plans we have set forth.

Partnering with Worcester Polytechnic Institute to aid in the scanning of city directories

The staff of WHM could collaborate with the Archives Department at WPI to continue the digitization of city directories in the museum. Since the chopping and scanning method to present 1892's directory book as a prototype proved successful throughout the project timeline, the WHM staff should continue to preserve the rest of the directories within digital replica.

Chopping and sheet-fed scanning every possible directory

Sheet-fed scanners are much more cost-effective than flatbed scanners. Every directory that has at least one duplicate should be utilized for this sheet-fed scanning process before reverting to flatbed scanning the single copy directories.

Utilizing the theater area as a permanent green screen exhibit

After some testing, the theater area is just large enough to put a green screen on the steps and project the live feed through the television already there. If necessary, the theater could still be

used for playing DVDs like it currently does, but when it is not being used for that purpose, the green screen can function as an extension to the Full-Pressure suit exhibit as the theater is located directly to the right of the suit.

Utilizing the green screen for more than just space related themes

The green screen is effective for space themes, but could also prove effective for displaying other aspects of Worcester's history. This could include anything from popular Worcester inventions, factory and mill settings, or even nostalgic photographs of the city, depending on what the museum would like to highlight. It could highlight a different aspect each week, going along with the idea of the *Stories They Tell* exhibit, which highlights a different artifact each week.

Incorporating an information panel for the different parts of the Full-Pressure suit

Having a photograph listing the separate parts of the Full-Pressure suit would provide additional information for the visitors. Many visitors would be curious to discover the different parts of the Full-Pressure suit and its functionality.

Employing an external loudspeaker for the steam calliope exhibit

The tablet computer, even though has a built-in speaker system, needs external loudspeakers to provide enough audio coverage to the visitors when interacting with the steam calliope exhibit.

Playing audio files of performance recordings on steam calliope

The current state of the calliope redesign allows visitors to interact with a simulated calliope keyboard and reproduce accurate calliope sounds. However, many visitors expressed a desire to hear full-length recordings of traditional calliope songs. This functionality may be critical for visitor engagement in the continued development of the calliope exhibit.

Our team's work during this Interactive Qualifying Project was largely experimental, and functioned as a measurement for the Worcester Historical Museum to assess the feasibility of the proposed overhaul of the Fuller Gallery. The *In Their Shirtsleeves* industrial history exhibit offered ample opportunity for the implementation of interactive exhibit design. This process was largely experimental, and therefore involved a lengthy period of research into the material contained within the exhibit, as well as the proper methodology to approach the design process. After the creation of prototypes for each facet of the proposed redesign, our team used a variety of evaluation measures to create a detailed set of findings and results. These findings and results are the basis for the recommendations that we provided to the Worcester Historical Museum for the continuation of the Fuller Gallery redesign.

Acknowledgements

The accomplishments of this project team are not solely the efforts of those four team members. During the team's seven week tenure at the Worcester Historical Museum, a number of different parties contributed in countless ways to the successful start to the redesign process of the Fuller Gallery. These individuals all helped our team maximize our potential for the Interactive Qualifying Project and deserve the utmost gratitude and respect for their efforts.

Our project sponsors, Mr. William Wallace and Mrs. Vanessa Bumpus, offered us an incredible opportunity to gain project experience at the Worcester Historical Museum. Bill and Vanessa both devoted a significant portion of their daily agenda to ensuring our success on this project. Their knowledge of the museum, along with their connections with other museums was paramount to the success of our project.

Mr. Chad Sirois, Communications Manager at WHM, often facilitated our team's communication with other museums and institutions. Chad contacted the New York Historical Society on our behalf and arranged a meeting between Mr. Chris Catanese, Director of Museum Administration, and our group. The insight from Mr. Catanese proved extremely helpful, as we frequently cited his expertise within this report.

Mrs. Robyn Conroy, WHM's Librarian and Archivist, offered us her insight and expertise regarding the Worcester city directories, which became an integral part of our project. Her help and guidance was essential to the conceptualization process for the city directory prototype.

Ms. Holly Izard, the Curator of Collections, helped us understand the types of artifacts the museum holds, along with some of the museum's policies regarding artifacts. The experience at the Worcester Historical Museum was an unforgettable one, bestowing upon us all a newfound appreciation of all the tedious and tireless work that she does for the museum.

Mr. Rodger Comeau, Facilities Manager at WHM, volunteered his thoughts, service, and equipment to our group. His assistance was key in the setup of the prototypes within the galleries, and he also provided us with some necessary equipment for the green screen exhibit.

Mrs. Jan Seymour, Director of Development, explained to us her role at the museum and helped us understand how our project could help the museum and its image. Her connections to museum members and local socialites helped us to better understand the importance of our project and how it affected the museum.

Clare Nadolski, facilitator of school tours at the museum, graciously allowed us to observe and interact within a handful of the countless tours she administered for local elementary school students. Furthermore, she offered her thoughts regarding the younger visitor demographic and their interactions in the museum galleries. Visitor tendencies and behaviors were a research topic critical to the success our project.

Office Manager, Lynn Soucy, introduced us to the museum and its role in the community. More importantly, she accompanied us each and every time that we stayed past closing at the museum and let us into the building every time that we arrived early.

Last, but most certainly not least, Receptionists Maria Rios, Ellen Parsons, Deanna Hodes, and Sharon Salmela were always at the front desk waiting for us with a warm and friendly greeting. Their warmth and kindness helped our team acclimate to the museum.

Words are simply insufficient in describing our team's gratitude to each and every staff member at the Worcester Historical Museum. The staff made this challenging experience a very memorable and rewarding journey, and we appreciate all of their efforts to help us achieve our project goals and feel comfortable at the museum.

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DEFINITIONS	Matthew Harrington
TABLE OF CONTENTS	All
TABLE OF FIGURES	Matthew Harrington, Keith Lundgren
TABLE OF TABLES	Keith Lundgren, Ali Fuat Becan
1 INTRODUCTION	Kyle Orfan
2 LITERATURE REVIEW	All
2.1 Introduction	Keith Lundgren, Kyle Orfan
2.2 Small Museums and the Community	Keith Lundgren, Kyle Orfan
2.2a Types of Small Museums	Keith Lundgren
2.2b Role of Small Museums	Keith Lundgren, Kyle Orfan
2.2b.1 Harbor History Museum	Keith Lundgren
2.3 Challenges of Small Museums	Kyle Orfan
2.3a Public Opinion of Small Museums	Kyle Orfan
2.3b Limited Funding of Small Museums	Kyle Orfan
2.3c Limited Space in Small Museums	Kyle Orfan
2.3d Visitor Interest Within Small Museums	Kyle Orfan
2.4 Exhibit Design Process	Keith Lundgren
2.4a Learning Outcomes	Keith Lundgren
2.4b Interactivity in the Design Process	Ali Fuat Becan, Matthew Harrington
2.4b.1 Solomon Northup Tour	Keith Lundgren, Kyle Orfan
2.4c Prototyping in the Design Process	Ali Fuat Becan, Keith Lundgren
2.4c.1 EcoTarium Robotic Arm Exhibit	Kyle Orfan
2.4d Evaluating in the Design Process	Keith Lundgren
2.4e Guidelines for Accessible Exhibit Design	Matthew Harrington
2.5 Recent Trends in Exhibit Design	Matthew Harrington
2.5a Incorporating Technology into Exhibit Design	Ali Fuat Becan, Matthew Harrington
2.5a.1 Green Screen and Blue Screen Technology	Kyle Orfan
2.5a.2 Exploratorium	Kyle Orfan
2.5a.3 New York Historical Society	Kyle Orfan
2.5a.4 Canadian War Museum	Kyle Orfan
2.5a.5 National September 11 Memorial and Museum	Kyle Orfan
2.5b Database Technology	Matthew Harrington
2.6 Worcester Historical Museum	Keith Lundgren, Kyle Orfan
3 METHODOLOGY	All
3.1 Objective 1: Database of Directories	Matthew Harrington, Kyle Orfan
3.2 Objective 2: Full-Pressure Suit	Keith Lundgren
3.3 Objective 3: Steam Calliope	Ali Fuat Becan
3.4 Summary	Kyle Orfan

4 FINDINGS	All
4.1 Introduction	Kyle Orfan
4.2 Design Process Findings	Matthew Harrington, Keith Lundgren
4.3 Objective 1: Database	Matthew Harrington, Kyle Orfan
4.4 Objective 2: Full-Pressure Suit	Keith Lundgren
4.5 Objective 2: Steam Calliope	Ali Fuat Becan
6 BIBLIOGRAPHY	All
7 APPENDIX	All
7.1 Appendix A – Survey for Fuller Gallery (Adults)	Kyle Orfan
7.2 Appendix B – Questions on Fuller Gallery (Children)	All
7.3 Appendix C – Survey for the Digitized Worcester City Directories	Matthew Harrington, Keith Lundgren
7.4 Appendix D - Interview Questions for Marla Quinones	Keith Lundgren, Kyle Orfan
7.5 Appendix E - Interview Questions for Vincent Manzo	Ali Fuat Becan, Keith Lundgren
7.6 Appendix F - Interview Questions for Jeffrey Forgeng	Ali Fuat Becan, Keith Lundgren
7.7 Appendix G - Interview Questions for Diane Strong	Matthew Harrington, Kyle Orfan
7.8 Appendix H - Interview Questions for Chris Catanese	Keith Lundgren, Kyle Orfan
7.9 Appendix I - Interview Questions for Jessica Colati	Matthew Harrington
7.10 Appendix J - Interview Questions for Joy Hennig	Kyle Orfan
7.11 Appendix K – Methodology for Survey Approach	All
7.12 Appendix L – Visitor Photograph/Video Consent	Kyle Orfan
7.13 Appendix M – Photographic/Media Consent Form	Keith Lundgren, Kyle Orfan
7.14 Appendix N – Learning Outcomes Survey for Teachers	Keith Lundgren
7.15 Appendix O – Sheet Music for Calliope Prototype	Ali Fuat Becan

Acronyms

IQP – Interactive Qualifying Project

WPI – Worcester Polytechnic Institute

WHM – Worcester Historical Museum

HHM – Harbor Historical Museum

CCHM – Carroll County Historical Museum

NASA - National Aeronautics and Space Administration

NEMA – New England Museum Association

PISEC – Philadelphia/Camden Informal Science Education Collaborative

IMLS – Institute of Museum and Library Services

GAO – Government Accounting Office

PDA – Personal Digital Assistants

RFID – Radio Frequency Identification

DBMS – Database Management System

QR Code – Quick Response Code

E-Book – Electronic-Book

Definitions

Interactivity – The ability for a museum exhibit to engage the visitor through various sensory activities.

Concept Design – A long-range project plan that provides direction and detail for a prototype.

Prototyping – Developing a first working model of a concept design.

Database – An organized collection of data.

System-user – Person(s) responsible for enabling a systems' operation.

End-user – Person(s) who use a product.

Green Screen – Special effect/technique for compositing two images or video streams together based on color hues.

Steam calliope – Musical instrument of pipe organ category that uses steam to produce whistles

E-Book – a digital version of a book; short for Electronic Book

Table of Contents

Abstract.....	i
Executive Summary.....	ii
Methodology.....	iv
Findings.....	v
Understanding Museum Visitors.....	vi
Worcester City Directory Findings.....	vi
David Clark Company Full-Pressure Flying Suit Findings.....	viii
Steam Calliope Findings.....	ix
Recommendations.....	xi
Acknowledgements.....	xiv
Authorship.....	xvi
Acronyms.....	xviii
Definitions.....	xviii
Table of Figures.....	xxiii
Table of Tables.....	xxiii
I: Introduction.....	1
II: Literature Review.....	4
I. Introduction.....	4
II. Small Museums and the Community.....	6
a. Types of Small Museums.....	6
b. Role of Small Museums.....	8
Harbor History Museum.....	9
III. Challenges of Small Museums.....	11
a. Public Opinion of Small Museums.....	11
b. Limited Funding of Small Museums.....	12
c. Limited Space in Small Museums.....	12
d. Visitor Interest within Small Museums.....	13
IV. Exhibit Design Process.....	14
a. Learning Outcomes.....	14
b. Interactivity in the Design Process.....	16
Solomon Northup Tour.....	18
c. Prototyping in the Design Process.....	19

EcoTarium Robotic Arm Exhibit.....	19
d. Evaluating in the Design Process.....	20
e. Guidelines for Accessible Exhibit Design.....	21
V. Recent Trends in Exhibit Design	22
a. Incorporating Technology into Exhibit Design.....	23
Green Screen and Blue Screen Technology.....	24
Exploratorium	25
New York Historical Society	26
Canadian War Museum.....	27
National September 11 Memorial and Museum	29
b. Database Technology.....	30
VI. Worcester Historical Museum.....	34
III. Methodology	36
Objective One: Develop a database system for the museum consisting of data from annual city directories	38
Sub-objective 1: Identify the users for the database	38
Sub-objective 2: Identify an appropriate database framework.....	39
Sub-objective 3: Populate the database with information from WHM collection	39
Sub-objective 4: Test, evaluate and refine the database based on user feedback	41
Sub-objective 5: Create a guidebook and tutorial for users of the database	41
Objective Two: The David Clark Company Full-Pressure Flying Suit.....	42
Sub-Objective 1: Identify learning outcomes for the Full-Pressure suit.....	43
Sub-Objective 2: Develop design criteria that satisfies learning outcomes and meets the other design objectives, such as feasibility and cost.....	44
Sub-Objective 3: Create a concept design and prototype based on the design criteria.....	45
Sub-Objective 4: Test, evaluate, and refine the prototype	46
Objective Three: Joshua Stoddard’s Steam Calliope	48
Sub-Objective 1: Identify learning outcomes for the steam calliope	48
Sub-Objective 2: Develop design criteria that satisfies learning outcomes and meets the other design objectives, such as feasibility and cost.....	49
Sub-Objective 3: Implement a concept prototype of the steam calliope	50
Sub-Objective 4: Test, evaluate, and refine the prototype	51
Summary	52
IV. Findings and Recommendations.....	53

Introduction	53
Design Process Findings	53
Findings for Objective I (Creating an Online Searchable Database of the Worcester City Directories) .	55
Design Process Approach	55
Preparation of the Directories	57
Compilation of Images.....	58
Searchability	59
<u>Recommendations</u>	60
Findings of Objective II (Creating a Prototype Redesign of the David Clark Company’s Full-Pressure Suit)	62
Understanding the Visitors and Learning Outcomes for the Full-Pressure Suit	63
Design Criteria for Full-Pressure Suit	64
Designs and Prototype of an Interactive Full-Pressure Suit Exhibit.....	66
Feedback from the Full-Pressure Suit Prototype	68
Recommendations	70
Findings of Objective III (Redesign of Joshua Stoddard’s Steam Calliope)	71
Learning Outcomes of the Steam Calliope Exhibit	72
Develop Design Criteria	73
Designs and Prototype of an Interactive Steam Calliope Exhibit	74
Evaluate Prototype and Refine.....	76
Recommendations	77
V. Conclusion	78
Bibliography	80
Appendix A: Survey for Fuller Gallery (Adults)	85
Appendix B: Questions for Fuller Gallery (Children)	88
Appendix C: Survey for the Digitized Worcester City Directories	89
Appendix D: Interview Questions for Marla Quinones	90
Appendix E: Interview Questions for Vincent Manzo.....	91
Appendix F: Interview Questions for Jeffrey Forgeng	92
Appendix G: Interview Questions for Diane Strong.....	93
Appendix H: Interview Questions for Chris Catanese.....	94
Appendix I: Interview Questions for Jessica Colati.....	95
Appendix J: Interview Questions for Joy Hennig	96
Appendix K: Methodology for Survey Approach.....	97

Administration of Survey	97
Disclosure Statement	97
Purpose of Survey	97
Appendix L: Visitor Photograph/Video Consent	98
Acquisition of Photographs and Videos	98
Disclosure Statement for Acquisition of Photographs and Videos	98
Purpose of Photographs and Videos	98
Appendix M: Photographic/ Media Consent Form	99
Appendix N: Learning Outcomes Survey for Teachers	100
Appendix O: Sheet Music for Calliope Prototype	101
Hot Cross Buns – 1798 (EASY)	101
Twinkle, Twinkle Little Star - 1761 (Trad. French melody) & 1806 - Jane Taylor (MEDIUM)	101

Table of Figures

<i>Figure 1: Snapshots of Alden Gallery (WHM, 2014)</i>	iv
<i>Figure 2: Snapshots of Fuller Gallery (WHM, 2014)</i>	iv
<i>Figure 3: Photograph of Harbor History Museum (HHM, 2013)</i>	10
<i>Figure 4: Photograph from "Going to the Chapel" (HHM, 2013)</i>	10
<i>Figure 5: The entrance to the Solomon Northup Tour</i>	18
<i>Figure 6: Screenshots from "New York and the Nation" app (NYHS, 2013)</i>	27
<i>Figure 7: Screenshots from the "Canadian War Museum" Smartphone Application</i>	28
<i>Figure 8: Screenshots from the "Explore 9/11" Museum Guidebook</i>	29
<i>Figure 9: Screenshots from the "9/11 Memorial" app</i>	30
<i>Figure 10: Carroll County Historical Museum's searchable database (CCHM, 2008)</i>	33
<i>Figure 11: Children participating in the Alden Family Gallery at the Worcester Historical Museum</i>	35
<i>Figure 12: Team member Keith holding "chopped" pages from the 1892 Directory</i>	59
<i>Figure 13: Pages from the 1892 directory loaded into the HP sheet-feeding scanner</i>	61
<i>Figure 14: An example of the OCR menu of the Adobe Acrobat Professional Suite</i>	62
<i>Figure 15: A professional "Green-Screen" exhibit at the American Museum of Natural History</i>	67
<i>Figure 16: The team interacts with the students of the May Street Elementary School</i>	71
<i>Figure 17: Team members Ali and Keith acclimating the green-screen in the WHM Theater</i>	73
<i>Figure 18: A Photograph of Robert Goddard that WHM intends to use for the green-screen exhibit</i>	74
<i>Figure 19: Virtual Keyboard from the mobile app FL Studio Mobile (Image-Line Software, 2013)</i>	79

Table of Tables

<i>Table 1: PISEC's Family-Friendly Exhibit Characteristics (Borun, 1998)</i>	17
<i>Table 2: Music Production Mobile Apps Researched in Criteria</i>	17
<i>Table 3: Tablet Computers Researched in Criteria</i>	17

I: Introduction

The history museum has become more than a collection of artifacts of the past to display; it introduces us to a living, breathing part of who we are and is testament to what we can accomplish. On the corner of Elm Street and Chestnut Street in Worcester, Massachusetts, the curious visitor will find a collection of artifacts unlike any other in the world, residing within the walls of the Worcester Historical Museum (WHM).

On their website, the museum notes what they determine as the backbone of Worcester's growth and success; "Innovative spirit and product diversity are the hallmarks of Worcester's industrial legacy." (WHM, 2013). Aside from being a city of industry, employing hundreds of thousands of skilled professionals, tradesmen, and intellectuals in the past, Worcester separated itself from other industrial cities through product variance. No single industry dominates the economic makeup of the city, as the local economy consists of everything from biotechnology to textile manufacturing. What started as innovative encouragement from investors in the early 19th century snowballed into a leading manufacturing center and ethnic melting pot in New England in the 21st century. From Ichabod Washburn's wire company and David Clark's aviation manufacturing company to Franklin B. Norton's grinding and abrasive company, Worcester has served as the incubator for a variety of leading companies over the centuries (Ibid).

David Clark Company, noted above, was a local manufacturing company specializing in aviation products. It was this Worcester Company that helped NASA make America's wildest dreams come true. In 1962 David Clark signed a contract with NASA that would forever tie Worcester to the Apollo Missions. Clark's High Altitude Full-Pressure flying suit design was far superior to that of any other manufacturer in the United States, and thus became the basis for the design of the spacesuits used for all following missions.

This icon of American history is one of the many gems that comprise the long and complex history of Worcester, New England's second largest city. With nearly four centuries of content, ranging from detailed accounts of the first public reading of the Declaration of Independence to the hippies getting together in the late 1960's on Congress Alley, Worcester's own rendition of San Francisco's Haight-Ashbury District, to the creation of the official smiley face, the museum is a unique resource, offering visitors a chance to connect to the Worcester community and learn something that they could not learn anywhere else in the world.

As part of their ongoing efforts to increase visitor engagement and interactivity since the installation of the Alden Family Gallery, WHM staff devoted a significant amount of thought to a redesign of the museum's permanent industrial history exhibit, *In Their Shirtsleeves*. The exhibit reveals the diverse and innovative industry of Worcester through a timeline of objects and artifacts dating back to the early 1800s.

The goal of this project was to, in collaboration with the Worcester Historical Museum, revitalize *In Their Shirtsleeves* through the use of interactive technology and incorporating this technology in order to bring the unique industrial heritage of Worcester to light. We developed three core objectives in order to accomplish our goal. The first step in our redesign process was to select two of the most interesting artifacts from the exhibit and highlight them through an interactive redesign. Two key artifacts that are essential to Worcester's unique industrial history include the full-pressure flying suit manufactured by David Clark Company, and the steam calliope invented by Joshua Stoddard. The museum director, William Wallace, said "We want the objects to tell a story to the visitors that they can relate to" (Wallace, 2014). Secondly, with these two artifacts in mind, we wanted to assess the feasibility of incorporating additional technology into the exhibit. The approaches to possible technologies included incorporating

tablet and smartphone applications. These approaches not only served to promote interactivity, but also to increase visitor retention through e-mail communication. In addition to the aforementioned objectives, we planned to create a digital and accessible database to contain the city records of Worcester; these records contain names, addresses, occupations, and other information about the millions of inhabitants in Worcester dating back to 1844.

This report is a chronicle of our team's proposed approach to the redesign of the *In Their Shirtsleeves* exhibit in the Worcester Historical Museum. In Chapter II, we provide the reader with background information on the exhibit design process, interactive exhibits and use of technology in exhibit design. In Chapter III, we include a detailed report on the methodology that our group plans to utilize in order to fully accomplish our goals and objectives. In Chapter IV, we present the reader with our findings and recommendations for the museum developed over the project term. Finally in Chapter V we conclude our report with an overview of the entire project experience.

II: Literature Review

I. Introduction

Museums hold a very unique role in the community today. The modern museum is a source of learning to all those who enter, and within the walls of most museums there lies a wealth of information that awaits the visitor that is curious enough to discover it. Historically, museums assumed a variety of roles in the communities that they served; the definition of a museum has had a variety of meanings through the centuries, from signifying a temple dedicated to the Muses to an organization preserving the human artistic and scientific creations (Alexander, 2007). Museums offer a physical, comprehensive view of the facts and figures that comprise everything around us, “[t]hey are places both children and parents can leisurely browse to discover the past present and future of humanity, the natural world, and the cosmos.” (Falk, 2000, pg.2).

New England is the intellectual capital of the United States, with more post-graduate degree holders than any other region (Census.gov, 2009). New England also boasts the presence of numerous and varied museums and galleries. There are art museums, history museums, science museums, children’s museums, and everything in between. The majority of museums in Massachusetts fall under the heading of small or mid-sized, and they often contain a very detailed collection of artifacts and information for visitors with very specific interests (NEMA, 2013). Each of these museums caters to a unique visitor profile, which heavily influences the design of the various exhibits within the museum. These museums each have different objectives in regards to their influence on the visitor population. While the objectives of the art and science museums are to inspire, the goal of the history museum is to inform and connect (Alexander,

2007). Smaller museums are not as widely known as their larger counterparts, but they have a much more personalized connection to the community that they serve.

Small museums establish roots in the community, and they constantly strive to present a specialized learning experience to the visitor population. Museums have a very special ability; they allow each visitor to take away a unique, personalized experience (Lord, 2002). While everyone in a movie theater may view the exact same film, each museum visitor theoretically views a different number of exhibits and artifacts, and views them in a different order (Simon, 2010). For each visitor at the museum, the interaction between the exhibit and the visitor builds a unique learning experience. The unique experience shared between the exhibit and the visitor gives small museums an advantage, as they are able to connect on a much deeper level with visitors. Large museums focus on attracting large numbers of visitors from around the world by offering exhibits that encompass broad topics, such as natural history or Renaissance art (Falk, 2000). Small museums have fewer exhibits, but those exhibits offer in-depth knowledge on subjects that often do not make it into the limelight at larger museums.

From the wealth of resources available, our team compiled a strong factual basis for the structuring and development of this project. In Section II, we describe the prevalence of small museums in the community, focusing on the types of small museums that exist and the role they play in their respective communities. Following this, in Section III we discuss the challenges that small museums face due to their size, resource and financial limitations. Exhibit design is the focus of Section IV, with data regarding the assessment of exhibit design and all of the relevant approaches to creating a functional and interactive museum exhibit. With this in mind, in Section V we explore recent trends in museum design, specifically those examples that involve the implementation of interactive technology. Finally, in section VI we explain how all of the

research specifically relates to our approach to the redesign of Worcester Historical Museum (WHM) and their *In Their Shirtsleeves* exhibit.

II. Small Museums and the Community

The American Alliance of Museums estimates that there are currently more than 17,000 registered museums in the United States alone. Out of those 17,000 museums a very small portion qualify as large museums, and even fewer receive federal funding (American Alliance of Museums, 2014). Whilst researching the role of small museums in the community, our team visited several small local museums. During our visits, museum staff presented us with data regarding the current state of museum staffing. The majority of staff members at these museums, and at many museums across the country, are volunteers. Although this is often troublesome for museums, the prominence of local volunteers illustrates the connection that museums have to their surrounding communities.

a. Types of Small Museums

Museums are useful sources of understandable information, providing reliable, authentic, and comprehensible presentations of art, history and science (Falk, 2000). The three primary types of small museums: the History Museum, the Art Museum, and the Science Museum, all offer subject specific collections. Art museums are devoted to one or more fields of art and emphasize the preservation and ownership of specific collections (Burcaw, 1998). Unlike art museums, science museums are focused with the understanding of forces of nature, principals of physics and scientific method (Ibid). History museums are much more selective than art and science museums, specializing in a particular field, time period, or geographic area (Ibid). For

example, Old Sturbridge Village focuses on a specific colonial time period; the Railroad Museum of New England focuses on the field of train history (Ibid). Each type of museum hosts a unique visitor profile, which has a prominent effect on exhibit design.

The differences in each exhibit are highlighted in various research studies. In a 1991 conference of historians and museum experts, individuals debated the roles and intentions of different exhibits, revealing a major difference between art and history museums (Karp, 1991). In his publication *Exhibiting Cultures*, Ivan Karp discusses the conference in depth. “The participants tended to think of the exhibitions as conforming to one of two models: either a vehicle for the display of objects or a space for telling a story. This in itself conformed to the great divide between participants from art museums and participants from cultural-history museums” (Ibid).

History museums enhance social cohesion by: 1) stimulating dialogue of complex issues; 2) accurately representing everyone within the society; and 3) promoting discussions between groups with disparate opinions (Rosenberg, 2011). Although history museums have the resources to unite a community, their approach has to utilize these resources to attract the local visitors. One of the most frequent internal debates found in history museums is whether to privilege the context or object in the approach. Is it more important to highlight the aesthetics of objects or propositional knowledge about them? Is a curator's message about the history of an object and its original context more engaging than the provenance of the object itself? (Karp, 1991). The answer lies within the visitors of the history museums and their interpretation of the experience presented by the material. “The important objects in a history museum are the commonplace, typical, popular, and once-plentiful artifacts of everyday living.” (Burcaw, 1998). The most effective collections in history museums are the ones the visitors can connect with (Ibid).

b. Role of Small Museums

One of the criteria developed by the Institute of Museum and Library Services (IMLS) and used to define a small museum is the size of the staff. Most small museums have a full-time paid or unpaid staff of five or fewer persons and are in fact closer to the minimum of one professional staff member required for IMLS funding (Katz, 1995). These small staffs have the ability to connect with their visitors on a much more personal level, as visitors often have a much stronger connection with the material presented in a small museum. “When people visit museums, they can do no other but bring their life histories and memories with them, maybe not ostentatiously nor even consciously, yet within reach.” (Kavanagh, 2005). While the public eye often perceives large museums as structured organizations with a recreational purpose, the public often expects a much more complex role from the small museum (Weil, 1990). These museums are less structured, and there is a public expectation for the museum and its contents to become a functioning member of the community. The museum is less of an attraction and more of a source of culture and information for the entire community to access and even contribute to. As a collective group, small museums are positioned to lead the process of making museums of all sizes and varieties “somewhat less ‘object centered’ and somewhat more ‘community centered.’” (Weil, 1990). Although museums offer a wide variety of information and resources to the community, the museum is also a benefactor of the wealth of information that the community can give back. The most effective aspect of small museums is to “... create new value for the institution, participants, and non-participating audience members.” (Simon, 2010).

The goal of the small history museum involves not only the parts of society directly related to their collections, but everybody. The successful small history museums account for all

ages, backgrounds, and genders, allowing the visitor to connect to the story the history museum tells (Burcaw, 1998). In essence, the society plays the largest part in determining the role of these small museums. The rapid change in society in the 21st century has radically altered the definition and role of small museums (Pastore, 2010). The successful small museums, therefore, are the ones that play an effective role in their respective communities (Ibid).

Harbor History Museum

A prime example of a small museum connecting with its community effectively through its exhibits is the Harbor History Museum (HHM) in Gig Harbor, Washington. The Harbor History Museum is a small history museum that strives to create opportunities for its community to experience the history of the Gig Harbor Peninsula through the collection, preservation and sharing of unique historical material (HHM, 2013). One of HHM's more recent exhibits, *Going to the Chapel: Faith, Friction, & Fellowship on the Gig Harbor Peninsula*, showcases the history of the early Gig Harbor Peninsula churches, ceremonies and celebrations through artifacts, photographs, and videos, highlighting the challenges within the communities between the different religious convictions (Ibid). The exhibit was actually the product of a collaborative effort between the HHM and dedicated Gig Harbor community members who worked on the exhibit for several months. "Just as churches brought people together during the early development of the Gig Harbor Peninsula, this exhibit continues to bring the community together to learn about and celebrate its multifaceted history." (Ibid). The HHM can be seen in Figure 3, along with a photograph from the exhibit in Figure 4.



Figure 3: Photograph of Harbor History Museum (HHM, 2013)



Figure 4: Photograph from "Going to the Chapel" (HHM, 2013)

Even though it can be economically rewarding, taking such an active role in the community is exhausting for small museums, as there are countless barriers that prevent them

from reaching their goals (Pastore, 2010). The next section will focus on some of those major barriers that small museums face.

III. Challenges of Small Museums

Although communities cherish the role that small museums occupy, these museums confront challenges on a daily basis. These challenges force museums and their staff to remain aware of the role that the challenges play in almost everything that the museums do. No two museums are alike, and small museums often vary wildly from each other. Despite this, as a community, small museums struggle with maintaining high public opinion, limited funding, lack of space, and continual visitor interest.

a. Public Opinion of Small Museums

Perhaps the most complex challenge that small museums face stems from their position in the public eye. Even the most conscious members of a community may not be current with the latest happenings at the small, local museums. Simply put, small museums lack the publicity that larger museums like the Smithsonian Museums receive. Consequently, small museums must tailor their exhibits to draw in visitors (Falk, 2000). For the small museum, new exhibits rely on word-of-mouth advertising to make the public aware of their presence (Golding, 2014). Typical advertising methods are not effective for reaching such a pointed and specific audience (Dean, 1996). This is a result of the conflict that small museums face between the role that they currently occupy and the role that they attempt to fulfill. As museums continue to evolve, so does the public perception of the quality of museum exhibits. Trends in museum design and presentation in the past two decades shaped what is now a public expectation for museum

exhibits to be more interactive and more holistic (Katz, 1992). Unfortunately, our findings in the following chapters illustrate that these approaches are not always feasible for local museums.

b. Limited Funding of Small Museums

Museums are typically non-profit organizations, therefore small museums lack the funding and other resources that larger museums have available (Ibid). The definition of resources may change depending on the content of each museum, but most museums require funding, expert endorsement, real estate, and staffing (Tohmo, 2004). As a result, the small museum is often a master of cross-functionality and resource management. Small museums effectively maximize the potential of the resources that they have available to them at any given time (Weil, 1990). “The clearest indications that a museum is well managed might be its ability to demonstrate that it makes the most efficient and effective use possible of the resources which it has available.” (Ibid). This is not to say that small museums are inferior to larger museums in any manner, rather they have a unique set of challenges and unique resources to combat those challenges. Creativity is the primary resource of these museums, and this lends credibility to the resourcefulness that museum staff praise so often (MacDonald, 2008). The financial restraints that small museums face are only a small portion of the challenges that continue to confront the museums and their staff on a regular basis.

c. Limited Space in Small Museums

The lack of physical space in smaller museums may also present a problem, as this limits the number of exhibits that the museum displays, and also limits the content of the exhibits. Limited space is especially troubling when trying to increase visitor retention, as fewer exhibits

will have the potential to engage visitors. Numerous case studies confirm that visitors do not spend very much time exploring the contents of a museum exhibit. In fact, “twenty minutes or less is a common duration for a single exhibition experience in a museum.” (Serrell, 1998). Even more troubling is the fact that small museums typically have enormous collections, and the exhibits that visitors see are only the “tip of the iceberg” (Wallace, 2014). Interviews with a several local museum officials suggest that a visitor will only take particular interest in a handful of exhibits, and the physical size of the museum floor is directly proportionate to the amount of exhibits that they will see. Exhibit quality greatly outranks the quantity of exhibits when considering the content of a small museum. Curators and exhibitions coordinators often devote their efforts to the maximization of the resources that already exist in the museum.

d. Visitor Interest within Small Museums

Visitor interest and engagement is very difficult for a small museum to accurately gauge and interpret. There are very few metrics that researchers may accurately cite when making assessments in regards to visitor interest in a specific exhibit. The most commonly cited metric is linger time, which is a direct measurement of the amount of time that each visitor spends at a single exhibit. Visitor engagement in an exhibit also bears a strong connection to the number of artifacts in the exhibit that the visitor takes an interest in (Serrell, 1998). Essentially, a visitor will spend more time at an exhibit if there is a significant amount of content, but only if they are first interested in the exhibit material. This connection is almost contradictory to many of the modern principles of exhibit design, which focus on minimalism and giving visitors only as much content as they desire.

IV. Exhibit Design Process

Exhibit design plays a crucial role in making a museum effective and impactful. A museum can contain a vast collection of unique information, but with a poor exhibit design, the information loses its ability to convey its value to the visitors. A museum exhibit, or collection of interpretive objects forming a cohesive unit within a gallery, has three key design areas: product-oriented activities, management-oriented activities, and coordination activities (Dean, 1996). Product-oriented activities include efforts to interpret the collection of objects. Management-oriented activities focus on providing the resources and personnel necessary for the design. Finally, coordination activities include keeping the management and product-oriented activities moving in the same direction (Ibid). An effective exhibit encompasses these areas efficiently, accomplishing the promotion of community interest within the museum, supporting the museum financially through popularity, and providing enlightening and educational experiences through these activities (Ibid). "The purpose of a museum exhibition is to transform some aspect of the visitor's interests, attitudes or value affectively, due to the visitor's discovery of some level of meaning in the objects on display - a discovery that is stimulated and sustained by the visitor's confidence in the perceived authenticity of those objects." (Lord, 2002).

a. Learning Outcomes

History museums design their collections to preserve information about a particular facet of history, but these collections first serve as a resource to help educate visitors. Simply having these resources available does not guarantee the success of a museum. The museum bears the responsibility of properly utilizing all of their resources to create interactive and engaging exhibits that draw and educate a multitude of visitors. "Museum learning is a vital component of

the lifelong learning that we now perceive as essential to the development of both the individual and his or but her society.” (Lord, 2007). This highlights the first step in the exhibit design process, determining learning outcomes. Learning outcomes are the desired information that museums intend the visitor to grasp from the exhibit, whether it is the importance of an artifact to its respective culture or the relationship it has to the visitor (Ibid). These learning outcomes are ultimately the particular concepts the visitor takes away at the end of a museum visit.

Once a museum determines its desired learning outcomes for an exhibit, there are many ways the museum may go about promoting the outcomes. One of the ways is to engage the visitors with a unique educational experience. Museums frequently face the task of remaining vigilant in the quest to interactively engage visitors and establish learning connections between the exhibits and the visitors. As generations evolve, the world becomes more adept to “neo-millennial” learning styles. Specifically, these are learning styles that involve immersing visitors with an engaging and suspenseful educational experience (Dede, 2005). Another strategy used to promote the learning outcomes of museum exhibits is creating a unique presentation of the exhibit. Perhaps the most crucial part of exhibit design is for the exhibit to provide a constructive and dynamic presentation of the content, rather than a static exhibit. Constructive and dynamic exhibit design approaches promote “free-choice learning”, which allows visitors to consciously learn something from the exhibit through a variety of sensory methods (MacDonald et al., 2008, p. 324). Museum exhibits simply are not effective when designers neglect to incorporate visitor learning in the design process (Ibid). Successful museum exhibits offer the most engaging environment possible, not only attracting different visitors, but encouraging them to interact with the environment as well.

The aforementioned *free-choice learning*, specifically in small history museums, may prove difficult. Modern museum research dictates that free-choice learning is a key focus for the effective design of museum exhibits (Ibid). For this reason, our team determined alternatives to existing displays of museum records to provide a tangible source/artifact for the visitor to engage with (Lord, 2007). Learning outcomes are undoubtedly a key component of the exhibit design process, and as our research touched upon previously, the concept of exhibit interactivity integrates almost seamlessly with the role of learning outcomes in the design process.

b. Interactivity in the Design Process

In general, museums focus much of their efforts on a younger visitor demographic (MacDonald et al., 2008). The age of a museum's visiting population plays a crucial role in exhibit design. In order to generate interest within the younger visitors, small history museums have to provide more than just information, they have to engage the visitors with interactive exhibits (Ibid). The styles of learning and “exhibit-visitor relationships” can provide an effective combination that could mark a learning experience in museums (Ibid). Essentially, through engaging the visitor, the exhibit is then able to achieve its intended learning outcomes.

Research from museum professionals proves that visitors gain new knowledge and perspective from museum exhibits when the exhibits use an approach that is visually and intellectually appealing (Bitgood, 2006). A late 1990’s study performed by four Philadelphia area museums took a much deeper look into the relationship between interactivity and exhibit design. The Philadelphian/Camden Informal Science Educational Collaborative (PISEC), comprised of the Franklin Institute Science Museum, the Academy of Natural Sciences, the Philadelphia Zoo, and the New Jersey Academy for Aquatic Sciences, composed a three-year

research and development project with the end-goal of improving museum exhibits in such a way that the exhibit promoted family learning. The study was broken up into three different phases:

- 1) What is family learning and how can we measure it?
- 2) Do specific exhibit characteristics facilitate family learning?
- 3) Do exhibits that have the seven characteristics of family-friendly exhibits produce measurable increases in family learning? (Borun, 1998).

The efforts of the PISEC research study yielded the development of seven key characteristics for family-friendly museum exhibit design. Located in Table 1 below, these seven characteristics serve as a guide for the creation of modern museum exhibits (PISEC, 1998). Each of these characteristic has its respective benefits, depending on what is looking to be achieved. For example, a benefit to a multi-sided exhibit is that families or groups are more likely to have a conversation about the exhibit if they are looking at it together, enhancing the visitor engagement with the material (USS Constitution Museum Team). PISEC's study has been utilized by various museums over the past decade, serving as the guidelines for creating interactive family-centered exhibits.

<u>Characteristic</u>	<u>Description</u>
<i>Multi-sided</i>	The family can cluster around the exhibit
<i>Multi-user</i>	Interaction allows for several sets of hands and bodies
<i>Accessible</i>	The exhibit can be comfortably used by children and adults
<i>Multi-outcome</i>	Observation/interaction are sufficiently complex to foster group discussion
<i>Multi-modal</i>	The activity appeals to different learning styles and levels of knowledge
<i>Readable</i>	Text is arranged in easily-understood segments
<i>Relevant</i>	Exhibit provides cognitive links to visitors' existing knowledge & experience

Table 1: PISEC's Family-Friendly Exhibit Characteristics (Borun, 1998).

Solomon Northup Tour

The Solomon Northup Tour, held at the National Underground Railroad Freedom Center in Cincinnati, is a shining example of interactivity in historical museums. The tour chronicles the life of Solomon Northup; a slave in the mid-1800's making his way to freedom in the northern United States. Visitors travel through a large expanse of the museum, moving through recreations of real scenes from Solomon's life, allowing them to feel what he would have felt nearly 150 years prior. "You imagine Solomon ... standing where you are standing ... you feel the cold, bitter hatred that crawls out to underpin a system such as slavery." (Johnson, 2013). Seen in Figure 5 is the entrance to the Solomon Northup Tour, highlighting the interactivity provided by its unique exhibit design.



Figure 5: The entrance to the Solomon Northup Tour
<http://media2.wcpo.com/photo/2014/01/30/SolomonNorthupTour>

The Solomon Northup Tour Exhibit uses visual and auditory learning through scenes of Solomon Northup's life based on the Oscar winning movie *12 Years a Slave*. Most people are engaged by movies and action clips, so combining that idea with a detailed historical timeline of this character effectively teaches the visitors about the trials and tribulations of an African American living during the era of slavery (Ibid).

c. Prototyping in the Design Process

Once interactivity fully integrates into exhibit design and functions to promote a specific set of learning outcomes, museums begin the process of prototyping their design. The prototyping phase helps the designers determine whether the exhibit successfully addresses specific learning outcomes. Museums often utilize a method of “progressive refinement”, where the designers first implement a prototype version of the design into the exhibit and subsequently make changes based on visitor feedback (Collins et al., 2004). This allows designers the opportunity to cultivate the removal of all imperfections while gaining user feedback, allowing for a more effective testing approach than surveying (Ibid). This process also allows designers to reassess the underlying theory of the design and exhibit overall (Ibid). Through the *progressive refinement* stage, exhibit designers might discover that the original learning outcomes were insufficient, or perhaps that the established interactivity of the design did not promote the desired learning outcomes. Progressive refinement is a practice that defines the structure of most modern museum exhibit designs, and there are numerous well-detailed examples in the past decade to illustrate the importance of progressive refinement.

EcoTarium Robotic Arm Exhibit

In the spring of 2013, a team of WPI students began the process of designing an exhibit for the Children’s Museum and Theatre of Maine (CMTM) in Portland, Maine and the EcoTarium in Worcester, Massachusetts. The CMTM and EcoTarium staff communicated to the students that the museum and its visitors would benefit greatly from the inclusion of a robotic arm exhibit (Stackable, 2013). This exhibit needed to address a specific set of learning outcomes, and the team conducted research into refining a prototype of a robotic arm (Ibid). The students

established a process of progressive refinement while prototyping and spent a great deal of time making changes to the prototype exhibit.

During the process of refinement, the students paid close attention to several different factors of refinement. First, the findings of the team state that many of the refinements were the result of the robotic arm's function without visitor interaction. Specifically, the robotic arm prototypes were often unstable in their movement, inadvertently jerking with or without visitors interacting with them (Ibid). This prompted the team to remove the prototype from the exhibit immediately and begin the process of design refinement.

Although these changes seem elementary, the team also spent a great deal of time evaluating visitor interaction with the exhibit. This evaluation process originally focused on team using a chart to note specific visitor interactions. After several iterations, the team removed the chart method from their evaluation process, as they found that their freehand notes provided much more detailed accounts of visitor interactions with the arm (Ibid). The combination of evolving prototyping methods and evaluation methods effectively represent the process of progressive refinement, as well as the process of prototyping in exhibit design as a whole.

d. Evaluating in the Design Process

Any scientifically inclined individual is likely to ask, "Why do we conduct an evaluation?" In the case of exhibit design, a designer initiates an evaluation with the intent of providing accountability for the use of public resources and/or to improve the designs performance. Evaluation provides feedback to both program design and execution (GAO, 2012). Evaluation is just part of the refinement stage in progressive refinement; it involves gaining user

input while testing an exhibit prototype, where the results provide insight to the exhibit design's interactivity, educational outcomes, and overall entertainment. One of the most common evaluation methods implemented by exhibit designers is evaluating the exhibit by its outcomes. Evaluating an exhibit design by its outcome means you define success by the measurable changes in engagement and general interest brought about by the changes/implementations made (Kryder-Reid IMLS, 2006). This goes one step further than a process evaluation, which looks at the design process from start to finish, assessing cause-and-effect relationships between the design and intended outcomes (Ibid). While process evaluations are very useful in determining whether the design process should be expanded upon, refined or expelled, outcome evaluations are useful in determining the effectiveness of certain aspects of the design process such as interactivity or learning outcomes (Ibid).

e. Guidelines for Accessible Exhibit Design

When designing an exhibit, it is important to consider the needs of people with mental and physical disabilities. People with disabilities are a part of a museum's audience, and it is prohibited to have an exhibit that does not cater to the needs of the disabled (Bumpus, 2014). The ultimate goal of an exhibit, beyond any desired learning outcomes, is to create an exhibit that is conveniently accessible to those with disabilities as well as those without disabilities (Majewski, 1996).

There are many details to consider when designing an exhibit that meets the Smithsonian Guidelines for Accessible Exhibition Design, the museum standard based on construction standards established for the Architectural Barriers Act of 1968, the Rehabilitation Act of 1973, and the Americans with Disabilities Act of 1990 (Ibid). It is vital that the museum considers

individuals who are hard-of-hearing, hard-of-seeing, wheelchair users, as well as those people with mental illness, cognitive disabilities, or learning disabilities (Ibid). According to the guidelines in place, exhibit content must capably present information to all of the senses. Specifically, exhibit labels must contain Braille to cater to the needs of the blind and any audiovisuals must be captioned in some way that caters to the deaf visitors (Ibid).

It is not uncommon to forget how much consideration and attention to detail is necessary in order to accommodate people with disabilities in an exhibit. Wheelchair users need the proper amount of space to be able to utilize any interactive exhibit or to read or look at any specific item in an exhibit (Ibid). Other design aspects like lighting and color need to be taken into account as well. An exhibit should be a comfortable place and proper color and lighting can make a visitor feel safe (Ibid). Finally, the size of the text on labels must cater to those who are hard of sight. This last regulation not only influences the exhibit labels, but any incorporated technology such as tablets or screens as well.

V. Recent Trends in Exhibit Design

Museum exhibits are as diversified as the content that they display, and therefore the literature on the exhibit design process is vast. Museum exhibit design focuses around two main principles: the raw information contained in the exhibit, and how the museum can best present this information to the visitor. Our research into both of these concepts yielded a wealth of background information, as well as numerous examples that will help to structure our final approach to the redesign. To illustrate the recent trends in exhibit design, we categorized the bulk of our research into the foci of technology in exhibit design, and the prominence of database technology in museum exhibits.

a. Incorporating Technology into Exhibit Design

Historical museums and antiquarian societies have a reputation for lacking the technological advancements that science museums and other learning environments typically employ (Laursen, 2013). Recent research dispels the previous theory that technology inherently distracts visitors from the educational value of the exhibit (Ibid). Technology is most powerful in the museum setting as a tool for visitors to continue their exploration of the museum's artifacts. Children are the driving force behind technological advancement in most settings, and the technological learning curve is almost non-existent in younger populations. Children are more receptive to social and technical interaction in a museum setting, and spend the most time of any demographic in interactive sections of exhibits (Hsi, 2005). This is not to say that children are the only visitors that receive the educational benefits of the museum, but rather that children have a higher potential to cognize the learning outcomes of each exhibit.

The modern technology user is no longer confined to younger age groups or individuals with higher disposable incomes, there are now representatives of all age groups, occupations, and socioeconomic backgrounds. This new market of technology users creates an interesting scenario for museums of all sizes, especially smaller museums like the Worcester Historical Museum. William Wallace, the Executive Director of the Worcester Historical Museum, has a particular interest in museums that include technology in exhibit design. The widespread use of modern technology, from tablets and smartphones to cloud based and online services, creates an expectation in the public eye that high-technology is a part of everyday life, and therefore museum visitors expect exhibits to incorporate technology as well (Lord, 2007). Technology is a resource for museums, and in order to maximize the value that visitors and the museum itself

gain from the use of technology, integration of technology into exhibit design must be a deliberate and calculated process.

All parties involved in the design of an exhibit must remain aware that there is a distinct difference between digitizing the information that is already in an exhibit and successfully integrating technology as a learning medium. A designer should always analyze what technology can provide to the exhibit that traditional mediums cannot. This can be as simple as using technology to lure visitors to less prominent exhibits, "...Technology has the ability to draw visitors into ideas and topics they might not have investigated otherwise." (Lord, 2007). The role of technology does not stop there however, as it must create a comprehensive visitor experience. The objective of a museum exhibit is not only to attract new visitors, but "... [to give] users a reason to revisit and continue to learn from the exhibit." (Ibid). Successful museums must have an evolving exhibit design, both in terms of the content that the exhibits include and in terms of the means by which the museum presents the content to the visitor.

Green Screen and Blue Screen Technology

The rapid pace of development for today's technology is especially poignant in the video entertainment sector of the high-tech market. Many of the most impressive cinematic compositions are the result of many years of advancement in green screen and blue-screen technology (Foster, 2010). This technology is fairly simple, as it involves the film subjects performing in front of a solid green or solid blue background. During the editing and final production of the film, cinematographers use a host of software tools to impose a certain image or video background upon the screen, giving the impression that the performers are present in a scene that would otherwise prove very difficult to compose. As of recent, green screen

technology is no longer exclusive to individuals with professional cinematography knowledge, and the range of applications for such technology is very diverse.

As mentioned earlier, there are nearly 20,000 museums in the United States alone, and many companies offer their expertise in exhibit design to those museums. In regards to the aforementioned green screen technology, Florida-based *Hands-On Green-Screen* provides museums of all sizes with an opportunity to engage the curious tech-savvy visitor. This company markets a downloadable smartphone app that engages visitors with green screen technology. *Hands-On Green-Screen* offers a contract to museums, where they create their own green screen environment on-site at the museum (Hands-On Green Screen, 2013). The museum then directs visitors to download the *Hands-On Green-Screen* app for a \$.99 fee. The museum receives 25% of all profits, and engages their visitors in a manner that they normally could not (Ibid). Guests record video on their smartphones and then use the application to impose a background behind their video (Ibid). Technology like this offers visitors the chance to become a part of the museum.

Exploratorium

The idea of incorporating technology into the visitor experience is far from new, but our research suggests that successful change builds upon the attempts of daring museums. The Exploratorium in San Francisco is one of the leaders in interactive exhibit technology. In a 2002 experiment, researchers developed a wireless based exhibit exploration system, where visitors could use personal digital assistants, or PDAs, to reveal more information about the exhibits they viewed. Although the PDA technology was slow and poorly integrated at the time, visitors responded positively, and were even able to access a museum guidebook, which contained a

large amount of related data not shown in the museum exhibits (Fleck, 2002). The findings from this experiment reveal that visitors have a strong interest in certain subjects. In addition, museum visitors are inclined to learn all that the museum can offer about that subject. Visitors showed a strong interest in saving pages from the guidebook for home reference and frequently used the PDAs to send links to their personal electronic mail (e-mail) addresses (Ibid). The Exploratorium does not use the same technology today, but the findings from this experiment helped form the design process for the current technology in place at the museum. Rather than carrying a PDA through the exhibit, each user receives a Radio Frequency Identification (RFID) enabled passport. The visitor then may scan the passport at each exhibit that they take a particular interest in, and at the end of their tour they will receive links to more information on those subjects via e-mail (Ibid).

[New York Historical Society](#)

Recent changes at the New York Historical Society support the theory of tailoring a unique experience to each visitor. The New York Historical Society pioneered the use of tablet and smartphone technology in the museum setting, allowing visitors to access the seemingly infinite archives of the museum in a digitized manner. The museum offers an application (app) for a host of smartphones and tablet devices that is available to all visitors free of charge (New York Historical Society, 2013). Although tablets and smartphones may have a reputation of distracting users from their surroundings, the applications designed by the museum actually increase visitor interaction in the various historical exhibits (Ibid).

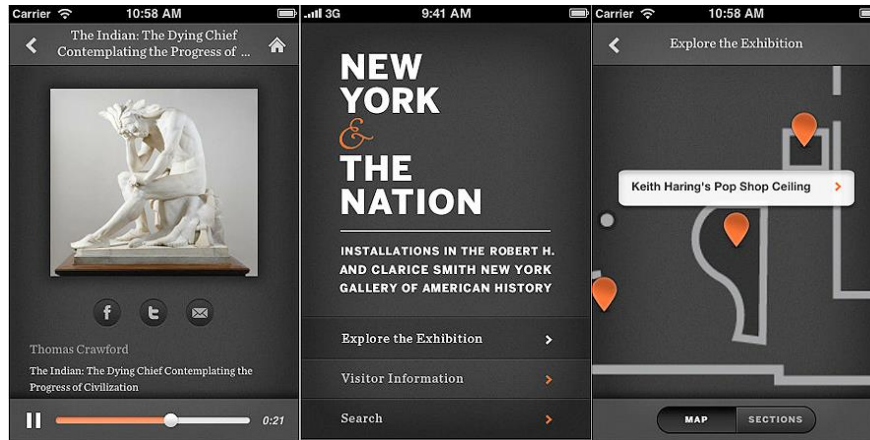


Figure 6: Screenshots from “New York and the Nation” app (NYHS, 2013)

Creating an application for mobile devices is a relatively simple way to increase visitor engagement through a technological medium that requires almost no learning curve. The New York Historical Society created the *New York and the Nation* app (seen in Figure 6) to give visitors access to a variety of digital content related to key exhibits in the Robert and Clarice Smith Gallery of American History (Ibid). Although our team did not get a chance to visit the gallery, we did spend some time using the smartphone app. The app offers a virtual map of the gallery, and for each exhibit the app presents videos, photos, and audio tours for the visitor. In addition, the app allows visitors to share the data via e-mail and social networking sites such as Facebook and Twitter (Ibid).

Canadian War Museum

Similar to the *New York & the Nation* application developed by the New York Historical Society, the Canadian War Museum in Ontario offers visitors a personalized interactive experience via their personal electronic devices. This app, pictured below, offers visitors a guided audio tour with much more in-depth information than the museum portrays through the

exhibits. In addition, the app provides visitors with a quiz for each exhibit in the museum, allowing the museum to test the visitor’s knowledge of the exhibit material in an interactive manner (Canadian War Museum, 2014). In a fashion reminiscent of the *New York and the Nation* app, the Canadian War Memorial offers visitors a detailed set of maps for the four main galleries of the museum. Visitors can access these maps via the smartphone application and use the maps to help plan their experience at the museum (Ibid). Although the Canadian War Museum application is not nearly as robust as the *New York and the Nation* application, the implementation of such an app for a smaller museum represents the growing trend of mobile technology in exhibit design.

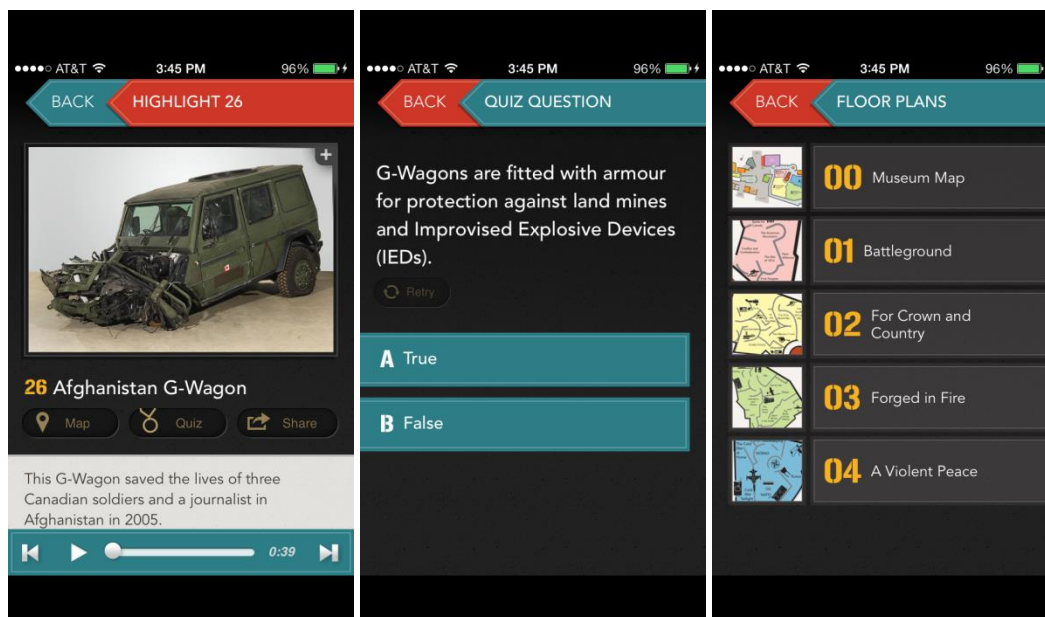


Figure 7: Screenshots from the “Canadian War Museum” Smartphone Application.
<http://www.warmuseum.ca/exhibitions/special-exhibitions/>

National September 11 Memorial and Museum

On the tenth anniversary of the September 11 attacks, visitors explored the National September 11 Memorial and Museum in New York City for the first time. This museum commemorates the lives of those that perished in the attacks, with a variety of artistic exhibits for visitors to explore indoors, as well as two memorial fountains commemorating the victims of each of the two World Trade Center towers (National/ September 11 Memorial and Museum, 2014). The memorial staff encourages visitors to use their interactive smartphone app, *Explore 9/11*, to access a wealth of resources. The app, seen in Figure 8, includes a guided walking tour of the World Trade Center site. This tour integrates an interactive map of the tour with a variety of stories, photographs, and video clips relating to the events that unfolded at each site (Ibid). Along with this guided tour, the app provides a detailed timeline of events for users to learn more about the September 11th attacks and the stories of those involved (Ibid).



Figure 8: Screenshots from the “Explore 9/11” Museum Guidebook.
<http://www.911memorial.org/explore-911>

The National September 11 Memorial and Museum also offers visitors an app for the exploration and investigation of the memorial pools located outside the museum. The walls that

surround these pools contain the inscribed names of all of the victims of the September 11th attacks (Ibid). The app, *9/11 Memorial Guide*, features an animated map of the memorial pools, and users may choose to view a digitized version of the walls, with all 2,983 names presented in a fully scrollable interface. Screenshots from the app can be seen in Figure 9. Visitors using the app have the ability to view a full profile for each name in the memorial. These profiles include a short biography about the victim, including their origin, date of birth, etc. (Ibid). Remarkably, the app also contains a search feature, allowing the user to search for the name of a victim, as well as the names of donors who helped make the memorial a reality (Ibid). This resource tailors almost exactly to the needs of the Worcester Historical Museum, and offers our team a great resource to model our database design after.

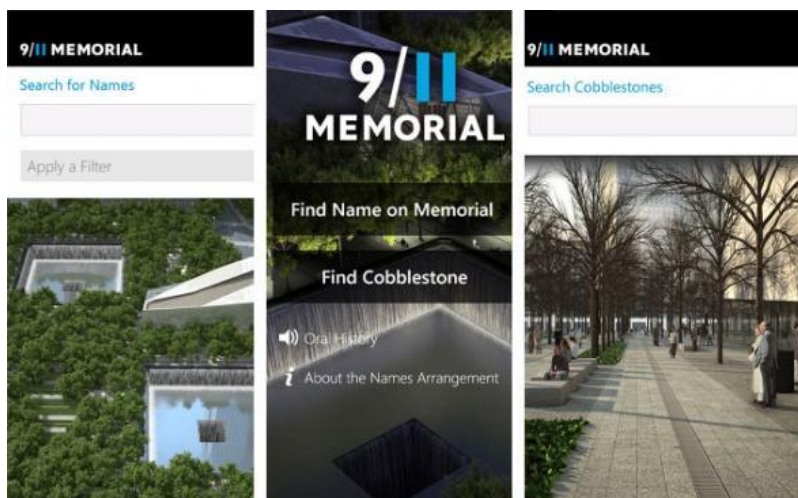


Figure 9: Screenshots from the “9/11 Memorial” app.
<http://www.911memorial.org/911-memorial-guide>

b. Database Technology

Information and knowledge are the keys to the advancement of individuals in today’s fast-paced, high-tech society. Although the casual investigator may not notice, most of the information that we access on a daily basis is a result of powerful database systems. These

computer-based systems allow almost any user to access countless volumes of information in a single place. The digital format that most of these databases embody implicate that they are usable in a host of unique platforms, including small personal devices like tablets and smartphones (Wang et al., 2005). The current state of technology integrates museum exhibits into multifunctional and interactive interfaces capable of providing as many images, animations, and details as possible. For instance, PDAs in science museums can display animations, images, and functions to guide the user through the anatomy or habitat of wild animals. Experiences like this promote a visitor experience that extends far beyond the dissemination of facts and data, allowing visitors to create their own unique learning adventure, with a world of content that they would not have access to otherwise.

Much of our findings on the creation of museum-specific databases are the result of a 1988 journal composed by research experts at the University of California at Los Angeles. Cathryn Gallacher, a research librarian, and Dale Treleven, the former Director of Oral History at UCLA, compiled a vast assortment of database related concepts into a single report. According to Gallacher and Treleven, there are three critical points of analysis to remain aware of when formulating a database design plan (Gallacher and Treleven, 1988).

The most imperative of these points to consider is the general nature of the historical collection (Ibid). This includes examining the variety of media that the museum typically contains (Ibid). The types of media in a museum exhibit may include documents, videos, and audio snippets.

Secondly, Gallacher and Treleven suggest that database designers consider the methodology of the entire design process (Ibid). The methodology of a database design involves the designer developing a detailed plan of action for the entire build process. This encompasses

all of the design points that the build will assess, along with an estimated timeframe for the delivery of the finished product (Ibid).

Lastly, these experts suggest that the database designers consider the system design itself (Ibid). The system design includes the computer system requirements and the technical design criteria (Ibid). The system design includes the computer system requirements and the specific database design criteria (Ibid). In terms of the database design and functionality, research asserts that each database is only as useful as the users that frequently operate it. The daily user of the database, or end-user, is therefore the framework to which a team tailors a database design. This means that the effective database is one that establishes a functional and effective interface for users of varying degrees of technological experience.

As previously mentioned, databases cater to two main user groups, end-users and system-users. System-users are typically higher skilled technology users, and are often administrators for the database or the institution that holds the database. With that in mind, the system-user is also a critical role to consider when building a database, as the system-user will inevitably access the database more frequently than the end-user (Ibid). According to Gallacher and Treleven, the database designer has a responsibility to incorporate an effective interface for the updating of database records (Ibid). In addition, a successful and effective database incorporates an architecture that allows for easy troubleshooting and quick repair of system issues (Ibid). The system-user is a critical stakeholder in the design of a museum database, and therefore holds a significant influence of the structure and design of said database.

After extensive research, our team extracted significant data from a variety of quality sources. As previously mentioned, the 9/11 Memorial and Museum offers visitors a mobile smartphone and tablet app, free of cost. This app is a mobile embodiment of the database of

records on the 9/11 Memorial and Museum website, which holds the names and biographies of all 2,983 victims of the September 11th attacks. The homepage of the app is very clear and easy to understand without sacrificing visual appeal. Search parameters include name, birthplace, flight number, employer, and first responder unit (9/11 Memorial Guide). This database offers the only searchable record of these victims, and presents the user with varying levels of detail regarding each topic of interest (Ibid).

The Carroll County Historical Museum (CCHM) in Delphi, Indiana also offers a fine example of searchable historical databases. The database contained at the Carroll County Historical Society allows users to search a variety of public records, including U.S. Census records, state tax records, and even marriage listings. This database bills itself as a Genealogy Index that searches individuals from directories who lived in Indiana at any point between 1862 and 1890 (CCHM, 2008). The interface, pictured in Figure 10, is very simple, and allows a variety of users to search for information they otherwise would not encounter. Although the current functionality of the database limits the user to only finding which records contain the name they searched, it returns the desired results and has an easy-to-use interface (Ibid).



Directories 1862-1890

[Search Database](#) [Search tips](#)

Last Name

First Name [Main Database Menu](#)

Figure 10: Carroll County Historical Museum's searchable database (CCHM, 2008)

As a small museum, the Worcester Historical Museum struggles to follow along with some of the most recent trends in exhibit design, but the museum reveals a strong interest in the incorporation technology. WHM is very progressive in regards to technology, and a database would help to broaden the interactive relationship already established between the museum and many of its visitors.

VI. Worcester Historical Museum

Worcester Historical Museum is a prime example of a small museum that strives to preserve the unique history of its surrounding community, as it is the only museum dedicated solely to the history of Worcester, Massachusetts. The museum therefore holds a very unique role in the city of Worcester. The museum and its staff are the keepers of Worcester's history, and each artifact contained within the walls of the museum tells a small piece of the city's history. William Wallace, the Executive Director of the museum, and Vanessa Bumpus, the Exhibitions Coordinator, are dedicated to keeping the museum current on all aspects of Worcester's history. Their efforts in recent years led them to pursue new, interactive exhibit designs. These new designs are all part of a museum-wide effort to keep the museum thriving in the community that it serves.

Following with the trend of museum interactivity, the recent redesign in the Alden Gallery of the Worcester Historical Museum transformed what was once a static gallery into a living, sensory exhibit. With help from the Boston Children's Museum (BCM), Director Bill Wallace and Coordinator Vanessa Bumpus created an environment that supports learning and physical engagement. The recent redesign in the Alden Gallery incorporates a portion of Worcester's history with a specific list of learning objectives. The gallery design intends to

transition between the industrial history gallery and the modern history gallery, all while providing visitors with a way to not only see Worcester's history, but also to interact with it and become a part of the scene (Bumpus, 2014). The Alden Gallery caters to the family demographic, serving as an example of the direction that the Worcester Historical Museum staff intends to lead all of the exhibits towards.



Figure 11: Children participating in the Alden Family Gallery at the Worcester Historical Museum.
<http://www.worcesterhistory.org/museum/alden-family-gallery/>

Thorough research and expansion of our team's knowledge in the museum field lends significant credibility to the goals and objectives that we plan to accomplish in our tenure at the Worcester Historical Museum. By working closely with the Worcester Historical Museum staff our project team intends to help the museum in its role as a resource in the local community and to connect with all individuals invested in the history of Worcester. With the help of our team's suggestions, the Worcester Historical Museum will have a useful set of tools to begin the transition towards a full redesign of the *In Their Shirtsleeves* exhibit of the Fuller Gallery.

III. Methodology

The goal of this project was to aid in the Worcester Historical Museum's (WHM) revitalization of the Fuller Gallery. Specifically, our team partnered with the museum to update the *In Their Shirtsleeves* industrial history exhibit through the use of interactive technology. Our team collectively focused our efforts on a few key objectives to accomplish this goal during our time with the museum. These objectives and their correlating sub-objectives are as follows:

Objective I: Develop a digital database that will allow museum staff and visitors to access the city records of Worcester.

- i:** Identify users for the database.
- ii:** Identify an appropriate database framework.
- iii:** Populate the database with information from WHM collection.
- iv:** Test, evaluate, and refine the database based on user feedback.
- v:** Create a guidebook and tutorial for users of the database.

Objective II: Develop an interactive design for the David Clark full-pressure suit exhibit that integrates the various other space related highlights of Worcester's industrial history. These include connections to Robert Goddard and the first prototype rockets.

- i:** Identify learning outcomes for the full-pressure suit exhibit.
- ii:** Develop design criteria that satisfies the desired learning outcomes and meets the other design objectives, such as feasibility and cost.
- iii:** Create a concept design and multiple iterations of prototype based on the design criteria.
- iv:** Test, evaluate, and refine the prototype.

Objective III: Develop an interactive design for the steam calliope exhibit that incorporates new technology and sensory interactivity. This design will highlight the use of auditory and visual learning cues as a source of visitor engagement.

- i:** Identify learning outcomes for the calliope exhibit.
- ii:** Develop design criteria that satisfies the desired learning outcomes and meets the other design objectives, such as feasibility and cost.
- iii:** Implement a concept prototype of the steam calliope.
- iv:** Test, evaluate, and refine the prototype

The museum frequently caters to a non-visitor population, often seeking information from the records currently held in the museum library (Wallace, 2014). Research from our team suggested that the modern database is an effective tool for museums to transition towards digital storage of records and information (Gallacher, 1988). Along with an incorporated database, our team focused on an interactivity-based redesign of the full-pressure suit and steam calliope exhibits to serve as examples for the continued redesign of the entire *In Their Shirtsleeves* exhibit. The success of these redesigned exhibits determined whether our approach was effective for exhibits with different content. The full-pressure suit is an especially poignant representative of Worcester's industrial heritage, and it drew the attention of many visitors. On the contrary, the steam calliope received very little attention from the average visitor, but offered ample opportunities for the implementation of interactive concepts, especially technology (Wallace, 2014). These exhibit redesigns provided a basis for our recommendations, which left the museum with information about all of the required information in order to continue the redesign of the remainder of the *In Their Shirtsleeves* exhibit. In the following sections we describe each objective and explain the approach we took to achieve them.

Objective One: Develop a database system for the museum consisting of data from annual city directories

The notion of the database originated from our team's initial interview with sponsors Bill Wallace, executive director of the Worcester Historical Museum, and Vanessa Bumpus, the Worcester Historical Museum's exhibitions coordinator. After meeting with the museum's Librarian, Robyn Conroy, and our sponsor Bill Wallace, we learned that the museum possesses city directories for every year dating back to 1844. The museum often receives phone calls from people asking for information from these directories about relatives that resided in Worcester many years prior. Consequently, they conveyed a desire to develop a searchable genealogical database of Worcester residents that were in the Worcester city directories. A searchable database would prove more efficient than physically searching the pages in the archives for a name.

Sub-objective 1: Identify the users for the database

As creators of this database, we catered our efforts towards two specific audiences, the system-user, and the end-user. The system-users, the WHM staff members for instance, are responsible for updating and editing the database. Collectively, system-users use the database the most. When we designed the database, we took into account the frequent changes and additions to the database that a system-user may need to make on a regular basis. Everything that the system-users do in regards to the database will have an effect on the experience that each end-user receives. The end-user is ultimately the person calling the museum and asking for information about a relative that lived in Worcester. While non-visitors are the majority of end-

users at this point, the museum also discovered an opportunity to allow visitors to easily access the directories.

Sub-objective 2: Identify an appropriate database framework

A good database is well organized, neat looking, and very easy to use and understand. Our second goal for the database was to create a user-friendly format that made the search process as easy as possible. This meant a couple things; first, that any instructions which would benefit the user experience were easy to understand and readily accessible; and second, that any information returned by the search was neatly sorted according to selected categories.

Our team debated the proper course of action for the digitization of the Worcester city directories with ample input from professional sources. Team members Matthew Harrington and Kyle Orfan had several years of university experience with database design and concepts, and therefore consulted a familiar WPI professor. Professor Diane Strong of WPI is an esteemed database expert, and has a wealth of experience regarding user interaction with database systems. Matthew and Kyle met with Professor Diane Strong to discuss the entire team's concerns regarding the design process and the unique challenge that the directories posed to the team. Matthew and Kyle then relayed the information from Professor Strong to team members Keith and Ali, as well as WHM.

Sub-objective 3: Populate the database with information from WHM collection

As we previously mentioned, the Worcester city directories in the WHM archives are of particular interest to both the visitor and non-visitor population. These directories served as the primary data source during the creation of building the database. We worked with the physical

documents rather than an electronic version of them. Due to the amount of information contained in the vast number of city directories coupled with the limited time we had, we as a group only worked with a fraction of the available information, to test the successfulness of our input processes. This troubleshooting provided WHM with a proven path to be followed in order to continue populating the database with the remainder of the information. The idea to focus on only developing a small section of the database was discussed in interviews with both Bill Wallace and the WHM Librarian Robyn Conroy.

From our interview with Diane Strong, we determined the most feasible and efficient approach to populating the database. From our discussion with Professor Strong, we concluded that visitors may prefer to see a digital version of the books, presented in a format similar to many popular E-Books available today. This would allow us to see if users respond to a more detail-oriented approach, or a simpler and more familiar format.

We then collaborated with the WPI Archives department with the help of Jessica Colati, Assistant Director for Curation, Preservation, and Archives. We used the Archives department's equipment to chop and scan the 1892 directory. This process involved separating the pages of the book and then loading them into a Hewlett-Packard sheet-feed scanner. We then compiled the scanned images into 50 page .TIF files for easy formatting. Throughout the project we used the Adobe Acrobat XI Premiere software suite to compile the .TIF files into Portable Document Format, or PDF file. By using the Adobe Acrobat software suite again, we converted the resulting PDF file to a searchable document. The searchability of the document is a result of the Adobe Suite's optical character recognition (OCR) tools.

Sub-objective 4: Test, evaluate and refine the database based on user feedback

Once we completed sub-objective 3 and had an initial, searchable prototype of the database, we assessed the functionality and accessibility of the database among a variety of audiences. Regardless of the end-user, we wanted to test the database so we could evaluate how it was received and determine what changes or modifications we needed to make.

Consequently, in collaboration with WHM staff, we sought out feedback from a variety of users that provided us with suggestions to improve the database. Before placing a finished prototype of the directory terminal on the exhibit floor, we first consulted with museum staff and project advisers to gain feedback on the E-Book. We presented the E-Book on a personal computer in order to receive feedback efficiently. After receiving a number of suggestions regarding the formatting of the book, we set out to create the final prototype.

Sub-objective 5: Create a guidebook and tutorial for users of the database

As briefly mentioned above in sub-objective 1, the needs of the system-user play a critical role in the creation of a database that successfully addresses all of the needs of the museum. The system-user will often be a museum employee who may have little database experience. Their responsibilities consist of updating and adding information to the database whenever necessary. Therefore, we searched for a method to keep the process of adding information simple, but also to provide a step-by-step tutorial of what to do and how to go about adding new information. In our interview with Professor Diane Strong of Worcester Polytechnic Institute and through our research of other museum databases, we developed a strong understanding of the process of implementing a database system that proves easy to maintain for the system-user. Our team specifically searched for museums that offered digital catalogues of

historic documents. This included the letters and personal memoirs posted on the American Antiquarian Society website as well as the searchable genealogical database on the Carroll County Historical Society website. These examples gave our team a reference point for successful iterations of the many types of digitized historical documents.

Our team then planned a trip to visit Chris Catanese of the New York Historical Society, located in New York, New York. Our team used the visit to gain more information about the creation and implementation of technology based interactivity, especially relating to the use of smartphones and tablets. One team member experimented with the New York Historical Society's smartphone application, whilst the others explored the capabilities of the newly implemented iPad application. Additionally, the team took care to ask about the process required to create a digital application for visitor use, asking questions that directly addressed costs, visitor input, and required resources.

Objective Two: The David Clark Company Full-Pressure Flying Suit

One of the most prominent artifacts within the *In Their Shirtsleeves* exhibit is the self-contained Full-Pressure High Altitude Flying suit, which highlights the industrial accomplishments of David Clark Company in the mid-20th century. In addition to playing a vital role in the nation's space program, David Clark Company had a major impact on the industrial history of Worcester, continuing its aerospace culture set in motion by Robert Goddard in the early 20th century (WHM, 2013). Working with Worcester Historical Museum, we worked to create a concept design for revitalization of the Full-Pressure suit in the exhibit by providing an interactive re-design to enhance presentation of the artifact. The following sub-objectives summarize our re-design approach.

Sub-Objective 1: Identify learning outcomes for the Full-Pressure suit

Each item within *In Their Shirtsleeves* has a unique role in the exhibit. Similar to Joshua Stoddard's steam calliope, David Clark Company's revolutionary Full-Pressure flying suit intends to both inspire and educate through several learning outcomes. Both of these artifacts intend to educate the visitor population, but the learning outcomes are specific to each artifact and its heritage. In its purest form, a learning outcome is a desired goal or takeaway for each visitor to the museum. For our first sub-objective, we needed to identify the learning objectives for the spacesuit artifact.

To accomplish our learning outcomes for David Clark Company's Full-Pressure suit, the project team performed multiple tasks. To begin, we conducted several interviews with WHM Exhibitions Coordinator, Vanessa Bumpus, to understand the learning outcomes from similar exhibits. We also held interviews with staff members of other museums, including the Boston Children's Museum (BCM), which collaborated with the WHM in 2013 to build the child-friendly and interactive Alden Gallery.

By conducting an interview with Ms. Marla Quinones, Director of Exhibit Design and Production at Boston Children's Museum, we hoped to learn more about learning outcomes for younger audiences. Quinones spearheaded the redesign of the Alden Family Gallery at the WHM, and therefore had a very strong knowledge of the WHM's visitor profile and the possibilities for new learning outcomes. We also received insight, via focus groups, from another museum stakeholder and elementary school teachers. Teachers at local elementary schools, specifically May Street Elementary School and the Seven Hills Charter School, expressed to our team the importance of museum learning for their students. By incorporating their opinions into

our research, we came up with appropriate learning outcomes for the Full-Pressure suit exhibit (see appendices D through J for interview questions).

Sub-Objective 2: Develop design criteria that satisfies learning outcomes and meets the other design objectives, such as feasibility and cost

Earlier, we highlighted how interactivity plays a crucial role in exhibit design. An interactive exhibit engages visitors and increases the likelihood that an exhibit will accomplish its learning outcomes. Interactivity also has the benefit of circulating information; when people around the community hear of a new and unique exhibit at the museum, it increases community interest through word of mouth. WHM is a small museum with limited resources, which can be a barrier to developing an effective interactive redesign for David Clark Company's Full-Pressure suit. Limited financial resources prevented us from utilizing a lot of interactive technology, thus we researched cost effective methods for making the Full-Pressure suit exhibit more engaging.

Worcester Historical Museum, along with the Boston Children's Museum, was our main stakeholder for the design criteria sub-objective. As mentioned above, both museums worked together in the redesign of WHM's Alden Gallery to make it more interactive and family-oriented. The Boston Children's Museum and Worcester Historical Museum utilized various non-technological interactive parts, in which we examined through in-depth interviews on the matter with BCM's Marla Quinones and WHM's Vanessa Bumpus.

Specifically, we interviewed Mr. Jeffrey Forgeng, the former curator of the Higgins Armory Museum. As a curator, Forgeng provided visitors an interactive experience by allowing them to try on pieces of medieval armor. His insight into interactivity was a useful starting point in contemplating our approach to the redesign of the Full-Pressure suit artifact (see appendix F for the full set of interview questions with Mr. Forgeng).

Sub-Objective 3: Create a concept design and prototype based on the design criteria

Early on in the project, we conducted an in-depth interview with Dominic Golding, a professor from Worcester Polytechnic Institute who specializes in exhibit design and prototyping, in regards to how effective a concept design is compared to a prototype as well as how to go about designing and prototyping. After understanding the advantages and disadvantages between a concept design and a prototype, along with developing a general idea as to how the designing and prototyping phases are executed, we sought out the expertise of multiple museums.

The methods we utilized to determine the effectiveness and processes behind a concept design and prototype were integrated research into various design processes done by other small museums such as the EcoTarium, also located in Worcester, Massachusetts, as well as interviews with relevant staff members of those museums. Our interviews with BCM's Marla Quinones and WHM's Vanessa Bumpus also included questions regarding the prototyping phase and how to go about it (see appendix D for interview questions with Marla Quinones).

Once we determined the effectiveness and common processes of both a concept design and prototype, we visited a variety of museums to gather examples and inspiration from a variety of different exhibits. During our visit at the Boston Children's Museum, we came across an array of unique exhibits, including *Bubbles*, an entire exhibit dedicated simply to producing bubbles, and *Arthur and Friends*, an engaging exhibit consisting of different interactive stations based off the 1990s television show. During our visit with the New York Historical Society, we came across a large amount of unique interactive technology in the *New York & the Nation* exhibit located in their main lobby, which highlights various aspects of New York's diverse history ranging from the colonial era all the way to the turn of the 21st century. The exhibit, which

utilizes augmented reality touch screens, a digital “living” painting that interacts with the visitor, and digital columns, was designed by Small Design Firm, an exhibit design firm headed by MIT graduate David Small. Small Design Firm has designed digital exhibits across the world, developing a unique take on interactive technology that attracts a multitude of visitors. Small’s designs have been utilized by museums such as the Holocaust Museum in Washington D.C. and the Imperial War Museum in London, England (Small Design Firm, 2011). We also visited a variety of interactive exhibits at the American Museum of Natural History in New York, New York. Along with our design criteria, we applied the ideas originated from the various relevant exhibits to create a design and prototype for the Full-Pressure suit redesign.

Sub-Objective 4: Test, evaluate, and refine the prototype

After developing a prototype that incorporated the desired design criteria and learning outcomes, we performed tests that evaluated the effectiveness of the prototype. Our first tests were basic assessments of the ease of set-up, ease of the program use, and quality of the outcomes that we tested amongst the group and WHM staff members. After the initial rudimentary tests, we developed visitor tests that rated the visitor’s enjoyment of the prototype experience based on a 1-5 scale, determined the visitor’s linger time, and took into account any feedback they provided. We mended the flaws and developed numerous iterations of prototypes until we found one that efficiently conveyed our goals. Once a prototype was found effective, Worcester Historical Museum would be able to utilize the prototype in the continued redesign of *In Their Shirtsleeves*.

The major methods we underwent for the testing phase consisted of informal interviews and focus groups. We conducted a focus group with forty 3rd grade students and two teachers from the May Street School in Worcester, Massachusetts who provided us with feedback on the

effectiveness of the prototypes in the gallery. The purpose of the focus group was to determine any feedback/ideas they had regarding the prototypes that we could utilize. We also held interviews/focus groups with a variety of elementary school students and their parents during the school vacation week of April 21st-25th. The students ranged from Kindergarten through 5th grade and we utilized these questions to get a sense of how effective our prototype was based on enjoyment level and linger time. Interview questions were very informal and almost completely impromptu, as the environment of an elementary school classroom is quite unique. Our team focused on asking questions in the simplest and most direct manner possible. The team did differentiate from this occasionally, asking students open-ended questions to gain interesting feedback. The prototypes were rudimentary, but they were developed enough to allow the elementary students to provide us with efficient feedback. We also held focus groups with WHM staff members to get their insight regarding the prototypes.

The last testing phase the group implemented involved evaluating the interactions and feedbacks that adults had with the prototype. On April 22, 2014 Worcester Historical Museum held a member appreciation event where we tested the Full-Pressure suit redesign with fifty adults over 30 years of age. The goal of the evaluation was to get an older visitor's perspective on the prototype, determining linger time and analyzing any feedback the adults had for us. We allowed the museum staff to interact with the prototype after they were given a short description and then compiled our observations and feedback received. Along with the feedback and data gathered from the younger visitor age group, we applied the feedback from the older visitors towards the improvement of the Full-Pressure suit prototype.

Objective Three: Joshua Stoddard's Steam Calliope

Joshua C. Stoddard, a Worcester native, submitted a patent request for the first steam powered calliope in 1855. The steam calliope very closely resembles a pipe organ. Stoddard's design requires a steam power source, which is infeasible in WHM's current environment. Our team believed that the steam calliope made for a great opportunity for the creation of an interactive exhibit. The goal with the steam calliope exhibit redesign was to present a digital simulation of the steam calliope in a multi-touch touchscreen device, integrating auditory and visual technology.

Sub-Objective 1: Identify learning outcomes for the steam calliope

Calliopes boast a history of usage in a variety of public spaces (road locomotives, riverboats, circuses) and artistic media (music labels, movies). Joshua Stoddard's steam calliope was the first model of the musical steam whistle instruments that inspired the invention of superior models like the compressed air calliope, the pyrophone and the calliophone. From our discussions with the WHM staff, we discovered that most visitors are unfamiliar with the steam calliope. For this reason, the redesign of Stoddard's steam calliope was paramount to increasing visitor awareness of the artifact. For our first sub-objective, we needed to determine the learning outcomes for the steam calliope.

We began our work with the steam calliope redesign by interviewing the WHM Exhibitions Coordinator, Vanessa Bumpus, and Executive Director, Bill Wallace. We also interviewed WPI professors who have expertise with interactive technology exhibits, specifically Jeffrey Forgeng and Vincent Manzo. Professor Forgeng has years of experience with interactive exhibits for children from his time as curator at Higgins Armory Museum and Professor Manzo specializes in interactive digital music design. We hoped to understand the different learning

outcomes that the steam calliope redesign could present. (See appendix E for the full set of interview questions with Professor Manzo).

In addition, we held focus groups at May Street Elementary School with a class of 3rd graders, and at Seven Hills Charter School with music teacher Ms. Kathy Holton and students from grades Kindergarten to 6. We hoped to learn what the children and teachers would like to see and interact with in an exhibit involving a musical instrument.

Sub-Objective 2: Develop design criteria that satisfies learning outcomes and meets the other design objectives, such as feasibility and cost

Developing the design criteria to present the steam calliope required us to brainstorm methods in which we could develop a prototype into a clear, family-friendly, and long-running exhibit. After an interview with Vanessa Bumpus and Bill Wallace discussing the design criteria for Stoddard's steam calliope, we aimed to provide as much hands-on interaction for the visitors as we could. However, we had to keep in mind the size and cost limitations presented by WHM.

To grasp a better understanding of how a musical instrument should be displayed in a museum, we researched and analyzed museums and institutions that are either dedicated to the presentation of musical exhibits or have connections to calliopes around the country, such as the Museum of Making Music in Carlsbad, California, and the Western Development Museum in Saskatoon, British Columbia. We conversed with the staff members of the aforementioned institutions via electronic mail (e-mail) in order to learn more about providing an educational and interactive visitor experience.

In addition, during our visit to the Boston Children's Museum, we came across *Making America's Music: Rhythm, Roots & Rhyme*, an interactive exhibit highlighting the different eras and styles of music. The exhibit contained a vast collection of different playable instruments,

ranging from a piano to a DJ/vinyl scratch table. The overall interactive exhibit design gave us insight into design criteria that is relevant to music-based exhibits, such as sound quality/volume and simplicity. The ideas developed from museum research and observations were used along with the interview responses from Mr. Wallace and Mrs. Bumpus to determine a detailed list of design criteria.

Sub-Objective 3: Implement a concept prototype of the steam calliope

After gathering details from the various museums, the project team was ready to embrace the challenge of developing a prototype of our concept design. During the prototype phase, we analyzed methods of displaying an audio-visual stimulus to the audience that would employ a ‘hands-on’ approach. Per the recommendation of WHM executive director Mr. Wallace, our team focused all calliope related research efforts on the acquisition of a tablet and application that would allow visitors to experience the auditory and visual interactions of a steam calliope.

We first searched for musical instrument tablet applications (apps) capable of importing digital audio files into the app. We inspected a number of commercially marketed mobile applications through their product descriptions and reviews that allowed for this type of functionality. For each application, we analyzed the app’s specifications and then searched a list of compatible tablet computers (Android and Apple tablets only) to select the matching models. Our team also searched for consumer reviews for each app, looking only for feedback from consumers that used the app for a purpose similar to our own. Finally, the team discussed the pros and cons of each app with the project sponsors.

After selecting a mobile app to complete our concept design, we continued to search for steam calliope owners to investigate the possibility of acquiring an audio recording of a steam calliope. Mrs. Debbie Fagnano, the steam calliope player of the *Steamboat Natchez* in New

Orleans, agreed to assist us when we requested recordings of each 32 keys of *Natchez*'s steam calliope. These note-by-note recordings allowed us to create a fully playable replica of the steam calliope's keyboard. This keyboard allowed visitors to recreate the sounds of an authentic steam calliope through a platform most had familiarity with.

Sub-Objective 4: Test, evaluate, and refine the prototype

As with any exhibit prototype, the steam calliope prototype needed to be tested, evaluated and refined in the WHM setting. By the recommendation of sponsors William Wallace and Vanessa Bumpus, we approached museum visitors and offered a brief description of the concept design, as well as our team's mission. The visitors were then offered the opportunity to interact with the prototype with minimal instruction from team members. This ensured that visitors would interact with the prototype in a manner very similar to the manner in which they would interact during a typical museum visit. This initial testing was used to test how intuitive the calliope app prototype was to someone who had never seen the app or played a piano based instrument.

After the rudimentary testing and making the necessary minor changes, we demonstrated the prototype to the focus group with K-6th grade students and music teacher Kathy Holton from the Seven Hills Charter School. The goal of this test was to not only test the level of intuition needed to play the calliope but to test linger time of the students playing the calliope and ask them what songs they would like to hear and/or play on the calliope. The group of students included young female students of different ages and skills. For example, one student was a piano player who visited the museum, while another student did not know how to play the piano and had never visited the museum before. These differences allowed for a larger sample of data

and feedback, which we used to determine any changes or additions that needed to be made, as well as what songs to incorporate into the application (see appendix for focus group questions).

The team's last testing phase implemented involved evaluating the interactions and feedbacks that adults had with the prototype. During the WHM member appreciation event held on April 22nd, we evaluated the calliope prototype with thirty adults over the age of 30 in order to get an older visitor's perspective on the prototype, determining linger time and analyzing any feedback the adults had for us. We tested the prototype with different members of the museum's board of directors; giving them a short description of the prototype and having them try it out. We applied the feedback from the older visitors with the feedback from the younger visitors in order to effectively enhance the calliope prototype.

Summary

The methods described above represent the culmination of the team's research and exploration of the current trends in museum exhibit design. Our team used the utmost care in choosing each method, evaluating the efficacy, ease of use, and accessibility of each one. Throughout the design process a number of unique challenges arose for each objective. These challenges prompted several tweaks in the applied methodology, which our team supported with additional research and professional opinions. The team extracted a unique set of findings from each method used in the design process, offering a strong set of data regarding the completion of each objective. The findings began as raw data extracted from the evaluation methods of each objective, with sources like surveys, interviews, and observations of visitor interactions. After a process of review and analysis by the team, the findings chapter presents these findings in a finalized and polished manner.

IV. Findings and Recommendations

Introduction

During the seven week duration of our project with the Worcester Historical Museum, our team employed various methods in order to make the interactive redesign of the *In Their Shirtsleeves* exhibit as effective as possible. We held interviews with staff members from other museums, various members of the academic community, librarians, archivists, and museum visitors. We held focus groups comprised of elementary school children and WHM staff members. We researched, analyzed and compared platforms, applications, and devices possible for the redesign. We also distributed surveys to the visitors at WHM to provide us with feedback regarding the effectiveness of our prototypes.

We discuss our data and findings from our research in the following sections. We begin with describing our findings about the design process in general, and then explain the exhibit specific findings. Lastly, we offer our recommendations for the museum and the three exhibit prototypes we developed.

Design Process Findings

As discussed in the Literature Review chapter, the design process determines the outcome of our efforts in regards to the exhibit design. Our team's work during the term yielded a wealth of findings. Some of our discoveries provided support for the specific objectives of our project, while others were general advice for the overall design process. The following findings played an integral role in our redesigns of both the Full-Pressure flying suit and the steam calliope, as well as the implementation of the digital database. Our interview with Mr. Chris Catanese, Director of Museum Administration at the New York Historical Society in New York,

NY, provided us the following examples of the common pitfalls that designers face when incorporating technology into history exhibits:

1. When utilizing computers within a design, the computers must be an exhibit entirely their own, rather than requiring visitors to refer to the computer for more information regarding an exhibit. Visitors can become frustrated or quickly lose interest if they have to keep going back and forth between the computer and the artifacts.
2. If the exhibit is to utilize a mobile device, ensure that phones are acceptable in the exhibit. The visitor must feel comfortable when using the device or it will hinder their desire to interact with the exhibit. If the mobile device functions similar to a feature already implemented in the exhibit, such as audio tours, the visitor will have less inclination to use the mobile device.
3. Stationary Tablets/Devices are much more effective than renting/utilizing mobile devices for they allow the visitor to have the sense that they are interacting with the exhibit rather than using a device to get more information. Visitors are more inclined to use a stationary device rather than use one of their own or one they have to ask permission to get. The process to rent can also be demanding.

Furthermore, our interview with Marla Quinones, Director of Exhibit Design and Production at Boston Children's Museum, gave us the following insight regarding the design process, physical interactivity, and working with children:

1. Similar to the insight from Chris Catanese, Marla highlighted that each audience takes away a different outcome and interacts differently with the exhibits. In particular, the age composition and learning styles of the audience members play the utmost role in

determining the group's interaction with the exhibit. Marla cited a common example, noting that if a younger audience attends the museum with an older audience, the older audience is less inclined to interact with the exhibits than if they attended without the younger audience.

2. Crude prototypes can prove just as effective as detailed ones. Designs composed of materials like cardboard and plastic can create prototypes that prove effective in determining if a particular exhibit design achieves the desired outcomes.

Findings for Objective I (Creating an Online Searchable Database of the Worcester City Directories)

Design Process Approach

As mentioned in the Methodology chapter of this project, our team originally planned to use Microsoft Access to manually enter the contents of each directory into the searchable platform. After a series of meetings with Robyn Conroy, the Worcester Historical Museum Librarian, and Diane Strong, a WPI professor specializing in database technology, we determined that this approach would not adequately fulfill the needs of the objective. Due to the database strategy being overly complicated, time consuming, and lacking interactivity, we determined that a digital e-book strategy would be more effective. Listed below are the findings we developed during the design process stage of the directory digitization.

Simple Designs Work Best

In interviews with both Marla Quinones, Boston Children Museum's director of exhibit design, and Chris Catanese, New York Historical Society's director of administration, the idea

that simple designs are often more successful than complicated ones arose. Quinones mentioned that visitor engagement is, at its very core, simple. As the complexity of the exhibit increases, the number of design related complications increases exponentially. There is, in theory, a target balance between simplicity and interactivity when designing an exhibit. Catanese reiterated this point by making note that simple designs can be just as effective as their more technologically impressive counterparts, as long as the simple display is engaging.

Visitors Often Have a Strong Connection to the Physical Presence of the Directories.

In an interview, Robyn Conroy explained that while a digital database would be useful for searching names efficiently, the visitors also like to see the physical directory itself to develop a stronger connection with the artifact. In effect, each time that a visitor searches through one of the directories, they are interacting with a genuine historic artifact. Similarly, Jeffrey Forgeng, the curator of the Higgins Armory Museum mentioned in an interview that too much technology could break the immersion factor between the visitor and the object. In the case of a database, the technology presented would overbear the historical connection between the artifact and the visitor.

A Searchable E-Book is a Simple, Accessible Design and will be Easy for Museum Staff to Maintain

In regards to the technical feasibility of the undertaking, Professor Strong indicated that a simpler approach such as a searchable E-Book would work best. Her recommendation stemmed from a concern regarding the immense amount of time and labor necessary to manually enter the required information into a Microsoft Access database. With many years of experience in database design, and recent project experience dealing with large amounts of data in database

formats, Professor Strong recommended that our team frequently evaluate our prototypes with the end-users. With this in mind, we altered our approach and searched for a high-quality alternative.

Preparation of the Directories

After consulting with several experts, our team developed a detailed replicable process to properly scan and digitize the directories in the WHM archives. Our team employed a cutting and organizing process following the recommendation of WPI Archivist Jessica Colati.

A Sheet Feeding Scanner Can Efficiently and Accurately Scan the Fragile Content of the City Directories.

During the course of our team's tenure at the Worcester Historical Museum, it became apparent that the Worcester Polytechnic Institute Archives Department possesses the required equipment to successfully create a searchable digital database of the WHM's collection of city directories. The Archives Department owns a number of different scanners designed for fragile documents, including a *Hewlett-Packard* sheet-feeding scanner that allows for the fast and accurate scanning of a directory from the museum's archive collection. These scanners are publicly available through a number of commercial office product suppliers. Mrs. Jessica Colati, an expert at the WPI Archives Department, offered our team a great deal of advice regarding the process of preparing the directories for the scanning process.

The Directory Pages had to be Cut and Trimmed to an Appropriate Size

Per Jessica Colati's recommendation, our team cut and trimmed the pages to an approximate 8 inch by 6 inch size in order to properly include all necessary information into the

images. Reducing the size of the pages and removing any imperfections (torn corners, flakes, etc.) is crucial in the scanning process. The images must be neatly organized and prepared in a uniform manner for the scanner to produce the highest quality images. During the scanning procedure, the integrated *Hewlett-Packard* software suite recorded the images into Tagged Image Files, or .TIF files. These .TIF files can contain an unlimited number of scanned images, but our team opted to limit each file to 50 images for space concerns. Each image in the file scanned at 600 dots per inch (DPI). These images are the maximum quality allowed by professional scanning equipment, and gave our team the most flexibility for future use.

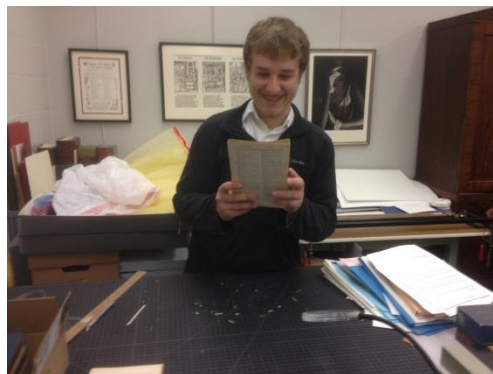


Figure 12: Team member Keith holding “chopped” pages from the 1892 Directory.

Compilation of Images

Adobe Acrobat Pro Software is the Most Accessible Method of Compiling Large Quantities of Directory Pages

After experimenting with various commercial software packages, our team discovered that the most effective method of compiling the many .TIF files from the scanning process would involve using the Adobe Acrobat Pro software suite. The software allows users to create a Portable Document Format, or PDF, very similar to modern professional documents. These PDF files allow users to combine multiple .TIF files into a single archive. As mentioned in our

Literature Review, the directories often contain more than 500 pages of information, which raised several concerns regarding storage. Adobe Acrobat Professional allowed us to compress nearly 4 gigabytes of raw scanned images into a 750 megabyte PDF file. After a side-by-side comparison, our team concluded that the images within the PDF were of the same quality as the images from the .TIF files. Although space is not a prominent concern while dealing with a single directory, it is a major concern in the continued digitization of the museum's collection of directories. With more than 150 years of directories to chronicle, the 1892 directory sets a precedent for the expected file size, as the 1892 copy is one of the most robust in the collection. As a result, the digitization of all directories in the museum archive would take far less space, making the continuation very feasible.



Figure 13: Pages from the 1892 directory loaded into the HP sheet-feeding scanner

Searchability

Optical Character Recognition Software is a Simple and Affordable Way of Making the Online Databases Searchable.

Per the recommendation of Jessica Colati, our team utilized the optical character recognition, or OCR, functionality built into the Adobe Acrobat software suite. After receiving

proper training, our team was able to create an integrated search function in the final document of the 1892 City Directory. After extensive testing, this feature proved very effective and allowed the user to find exactly what they searched for. Users now have the ability to easily search for any specific word that may or may not exist in the directory. Each search returns a detailed listing of each time that the desired search criteria occur in the book. The searchability of the 1892 directory offers the end-user a familiar and recognizable format that accurately displays the contents of the directory in an aesthetically pleasing manner.

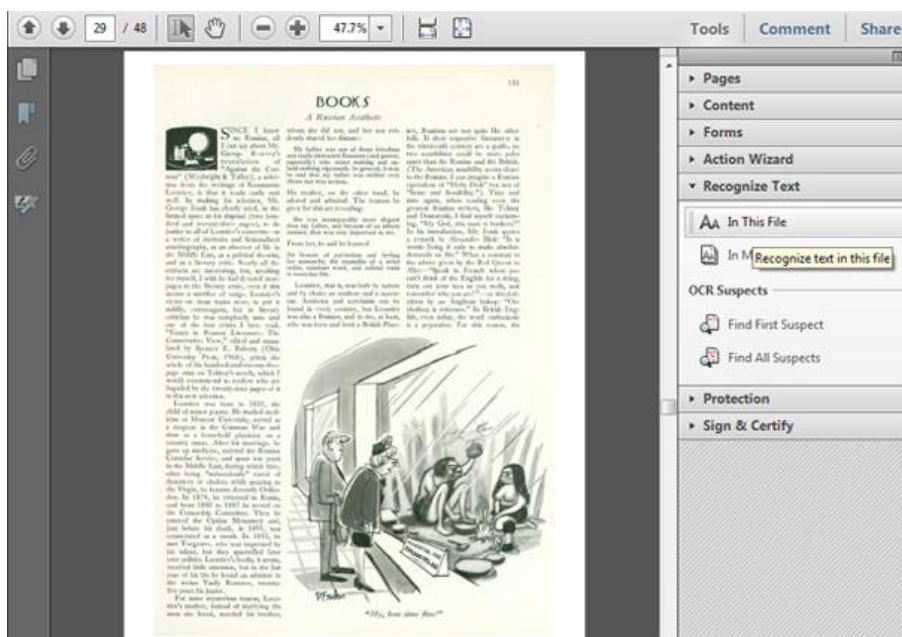


Figure 14: An example of the OCR menu of the Adobe Acrobat Professional Suite.

Recommendations

Partnering with Worcester Polytechnic Institute to aid in the scanning of city directories

The Archives Department at WPI has a vast amount of knowledge and experience, as well as the necessary equipment in order to scan old documents like the Worcester city directories, which could prove especially useful in the continuation of digitizing the city directories. Our team's access to the resources and expertise of the WPI Archives Department was the result of our status as WPI students. Essentially, our team received access to the

aforementioned resources for the purpose of completing our IQP. During our meetings with archivist Jessica Colati, we discussed the possibility of establishing a partnership between the Worcester Historical Museum and the Worcester Polytechnic Institute Archives in order to continue the process that our team began. Other local institutions, such as the Worcester Public Library and the Antiquarian Society, may also have a strong interest in participating. A partnership with WPI would not only prove affordable for the Worcester Historical Museum, it would allow these respected local institutions to work together in preserving the history of the great city of Worcester.

Chopping and sheet-feed scanning every possible directory

From our research, the most efficient way to produce high quality scanned pages of city directories is through the chop and scan procedure previously mentioned. This involves removing the binding of the book and putting the separated pages through a sheet-fed scanner. This method saves not only time but money as sheet-fed scanners are much more cost-effective than flatbed scanners. After much discussion with the museum staff and Joy Hennig of the Worcester Public Library, our team is aware that this procedure does damage valuable historic artifacts. We suggest that the procedure only involve directories with multiple duplicates. The remaining directories could become part of an overhead scanning procedure. Although the directories will become quite damaged, there is a possibility that professionals could re-bind the books. The scanning of these directories is incredibly valuable to the historic community, as these digital copies will remain for many future generations.

Feedback regarding the prototype 1892 city directory

The initial feedback concerning the 1892 directory centered on the visual appeal of the product. The museum staff and project advisers interacted with a PDF file formatted similar to an E-Book. Several critics presume that the E-Book interface would help visitors and system-users, as the format is very familiar. On the contrary, some critics supposed that an animated Flip-Book would help visitors connect with the exhibit in a more interactive way. From these suggestions, we set out to find a software suite that would allow for the creation of a fully functional Flip-Book of the 1892 directory. We decided that providing the museum with both formats of the directory would allow them to test and evaluate long after the IQP culminated.

The final prototype for the 1892 directory now resides in the Fuller Gallery. There are two desktop computer terminals positioned adjacent to each other in a location with a seated desk. Each terminal contains a copy of the full 1892 directory, as well as separated copies of the business and citizen directory components. These terminals utilize the Adobe Flash Player and Adobe Acrobat Reader software suites. The museum staff can easily switch the directory that is displayed on each terminal. This is critical, as only one of the terminals is currently handicap accessible, and handicapped visitors must have unrestricted access to all of the features of the exhibit. Signage containing instructions for use, along with sample search criteria, is propped next to the terminals in order to ensure proper visitor interaction. Additionally, there is a visitor feedback survey adjacent to each terminal.

Findings of Objective II (Creating a Prototype Redesign of the David Clark Company's Full-Pressure Suit)

We utilized various research, interviews, focus groups, and surveys to bolster our redesign of the David Clark Company Full-Pressure Flying suit. The following sections discuss

our findings pertaining to the learning outcomes, the design criteria, and the prototyping process of the prototyping process.

Understanding the Visitors and Learning Outcomes for the Full-Pressure Suit

Our first task for the redesign of David Clark Company's Full-Pressure suit was to determine the learning outcomes for the Full-Pressure suit exhibit. Before we determined any immediate learning outcomes, the project group needed to determine the most common visitor age groups in order to cater to whom we should cater the learning outcomes.

The Target Age Group for the Exhibit includes Children under 12 and Adults over 30.

Based on the frequency of the visitors during the project timeline, the most common age groups were elementary students under 12 and adults over 30. Through interviews with the WHM staff and our observations of the different galleries, the project group realized that the learning outcomes would have to pertain to various ages. Once the project group determined that the common visitors were very different in regards to age, the next step was to understand how much information the younger visitors could grasp in order to make the learning outcomes as efficient as possible.

Elementary Students Can Grasp Complex Concepts Much Like Adults

Our next finding was that elementary students were intelligent and could grasp difficult ideas such as the green screen technology. A focus group comprised of the 3rd grade students at the May Street School in Worcester, MA, led us to find that children understand not only what a green screen is, but how it works.

The Learning Outcomes for the Full-Pressure Suit Must Highlight Worcester's Involvement in Space

Our final finding highlighted the learning outcomes for the Full-Pressure suit, which included educating the visitors on Worcester's various involvements in the space industry. We determined these learning outcomes through an interview with WHM staff members (Bill Wallace and Vanessa Bumpus), discussing with them the different experiences they had with the Full-Pressure suit, as well as the information they would like to incorporate for the Full-Pressure suit.

Design Criteria for Full-Pressure Suit

After determining the learning outcomes for the Full-Pressure suit, the project team developed the design criteria that would encompass both interactivity and the learning outcomes.

The Full-Pressure Suit Exhibit Redesign Must Encourage Visitor Engagement

Our first design criteria finding was that the design should incorporate some sort of hands-on experience with the space industry, although it could not be about trying on an actual suit due to safety hazards/hygiene reasons along with the difficulty in getting an authentic suit to let visitors try on. This criterion was highlighted in interviews with Bill Wallace and Vanessa Bumpus. They emphasized that putting on helmets or gloves could present hygienic issues, as well as the fact that getting a replica suit to try on is extremely difficult and are only available for small time frames throughout the year.



Figure 15: A professional “Green-Screen” exhibit at the American Museum of Natural History

Rewards Increase Visitor Engagement in an Exhibit

Our next design criteria finding was that, for younger visitors, rewards aid in providing stimulus to the exhibit, which in turn aids in portraying the learning outcome. Whether it is a simple token such as a picture or sticker or a simple action such as a light going off, rewards help younger visitors appreciate and remember the exhibit. This criterion was uncovered from interviews with both Marla Quinones, Director of Exhibit Design and Production at Boston Children’s Museum, and Jeffrey Forgeng, the Higgins Armory curator.

Technology is Not Always Necessary

Our last design criteria finding was that excessive technology could break the immersion factor. In an interview with Jeffrey Forgeng, he emphasized that a good balance between technology and hands-on interactivity leads to the most efficient design. He noted that the Higgins Armory Museum utilized only some technology such as touch screen quizzes to test the visitors of their knowledge because too much would have reduced the authenticity of the artifacts. The more genuine an exhibit design is, the greater chance the visitor will connect with

the artifacts and not the technology promoting the artifacts. This does not necessarily mean that all technology is ineffective. Marla Quinones iterated that technology can be helpful, but is not always necessary. She emphasized that physical interactivity can be just as effective as technological interactivity, as long as the physical interactivity

Designs and Prototype of an Interactive Full-Pressure Suit Exhibit

After developing our design criteria for the Full-Pressure suit, the project team began developing designs and prototypes for the Full-Pressure suit that comprised of both the design criteria and learning outcomes.

Green Screen Technology Best Suits the Redesign of the Full-Pressure Suit

Green screen technology, or Chroma keying, is the process of projecting, or keying a background across a solid shade of green. The color green is used because it is the color shade farthest from your skin color, so it is easy for these green screens to portray the body. Perhaps our most intriguing design finding was that incorporating a green screen/Chroma key technology would satisfy design criteria and learning outcomes. During a tour of the Boston Children's Museum in Boston, Massachusetts, the project group discovered the *Arthur and Friends* exhibit that highlights a green screen and Chroma key technology. The exhibit has a list of video clips based on the TV show that displays as the background of the visitors in front the green screen. After some research into the use of green screens, the project group found that the technology was not only cost-effective, but could be utilized to give the visitors a 'hands-on' space experience without any hygienic issues.

Other Museums Utilize Green Screen Technology for a Variety of Uses

Our research led us to discover that many museums currently utilize green screens for various reasons. Through our trip to the American Museum of Natural History (AMNH) in New York, New York, we realized that museums may use green screens as a form of visitor attraction and take-away, allowing visitors to have photographs as souvenirs. AMNH had a green screen set up and was taking pictures of visitors in front of a green screen and allowing them to choose a theme-related background to be in front of (shown in Figure 15 above). There are two types of uses for the green screen

***VidStudio* is the Most Accessible Chroma Keying Program**

After deciding that the design would be centered on the green screen idea, we found two Chroma key programs that we could utilize for the redesign: *123 Image Magic*, an affordable and easy to use program used for changing backgrounds on photographs taken with a green screen and *VidStudio*, a free program used for projecting a live stream cast of a visitor in front of a green screen. After extensive research and various trial runs, we found these two programs were not only the most cost-effective programs, but were easy to use and effective. A comparison chart of the different Chroma keying programs that were considered can be seen in Table 2 below.

The Full-Pressure Suit Redesign Does Not Have to Consist Only of a Green Screen

Along with the green screen, the project team pondered incorporating other design concepts into the exhibit. We found that incorporating information highlighting different parts of the Full-Pressure suit would be helpful to visitors who are interested in the design of the suit. A

student proposed this idea through the focus group with the 3rd grade students at the May Street School. When we visited the school, the eager students were more than happy to spend class time discussing redesign ideas.

The focus group also led us to find that different colors are of high interest to children. When asked what improvements they would like to see for the Full-Pressure suit redesign, more than one student responded by recommending we make the gallery entirely one color, with one girl exclaiming “I would like to see the suit in pink!” We also found various space related videos and pictures of Worcester’s space history through research that we could utilize not only for the green screen, but potentially a screen based exhibit in front of the Full-Pressure suit.



Figure 16: The team interacts with the students of the May Street Elementary School.

Feedback from the Full-Pressure Suit Prototype

The final step of the redesign process involves testing, evaluating, and refining the prototype of the Full-Pressure suit design.

Lighting is Important for Proper Functioning of the Green Screen

After preliminary tests and research, we found that lighting plays a crucial role in green screen technology, so we had to find not only a large enough space for the green screen, but provide multiple lighting options. The Chroma key programs can be very sensitive to the background lighting on the green screen, so after various trial runs and different lighting techniques utilized, we found a set-up that functions well using two home spotlights.

Location Played a Large Role for the Green Screen

After we found that *VidStudio* is the most accessible Chroma key software, we tested the program out in three different parts of the museum: the entrance to the Fuller Gallery, the auditorium, and in the Fuller Gallery Theater. After some testing, the theater area is just large enough to put a green screen on the steps and project the live feed through the television already there. While a permanent green screen worked best in the theater, as it was convenient for the younger visitors during the school vacation week of April 21st to first see the Full-Pressure suit and then go view themselves on the moon theater right next to the Full-Pressure suit, the portability would be limited if it were installed in the theater. On the other hand, the auditorium can only be used occasionally for special occasions as it houses the school tours and other various events and the entrance to the Fuller Gallery location would cause too much visitor traffic.

When Urged, Adults Enjoyed Getting Photos Taken On the Moon

On April 22nd, we presented our prototypes to members of the Worcester Historical Museum board, where we earned some insight on the older visitor's perspective. We received feedback from 50 adults over the age of 30 during a member appreciation event.

Following the event on April 22nd, we tested the prototypes with numerous visitors during school vacation week and asked them to fill out the survey located in Appendix.

Recommendations

Use the Green Screen Theater Space to House the Green Screen Exhibit

If necessary, the theater could still be used for playing video footage as it currently does, but when it is not being used for specific events for that purpose, the green screen can function as an extension to the Full-Pressure suit exhibit as the theater is located directly to the right of the suit. The only drawback would be that it may not be portable if it was installed permanently live in the theater.



Figure 17: Team members Ali and Keith acclimating to the green screen in the WHM Theater.

Utilize the Green Screen for more than just space related themes

The green screen can be used for not only space themes, but possibly other industrial Worcester aspects such as the factory, depending on which one the museum would like to

highlight. It could highlight a different aspect each week, going along with the idea of the *Stories They Tell* exhibit, which highlights a different artifact each week.



Figure 18: A Photograph of Robert Goddard that WHM intends to use for the green screen exhibit.

Incorporate an information panel for the different parts of the Full-Pressure suit

Having a photograph of the Full-Pressure suit with a full listing indicating the separate parts would provide additional information for the visitors. Many visitors do not know the different parts of the Full-Pressure suit and are curious about how it works.

Findings of Objective III (Redesign of Joshua Stoddard’s Steam Calliope)

As explained in the Methodology chapter, the project team utilized various research, interviews, focus groups, and surveys to support our design process of the Joshua Stoddard’s steam calliope. We organized the section based upon our sub-objectives, highlighting our various findings with respect to each task.

Learning Outcomes of the Steam Calliope Exhibit

Our first objective in redesigning the steam calliope exhibit was to understand the expectations of the WHM staff, museum experts, and general museum visitors when hearing of an exhibit with musical instruments. The staff wanted this exhibit to address that the musical instrument was patented by Worcester resident Joshua C. Stoddard, present the artistic aspects of the instrument (i.e. how it is played), and then effectively present calliope music to the audience. The redesign needed to appeal to visitors and allow them to enjoy exploring the sounds of the calliope, while also offering the opportunity to listen to the calliope's traditional play styles.

We interviewed Executive Director Bill Wallace and Exhibitions Coordinator Vanessa Bumpus in order to determine the learning outcomes they asserted the visitors should achieve from a musical exhibit that presents Stoddard's steam calliope. They informed us that the exhibit should present what a calliope is and the sounds it creates, while showing the visitors that a Worcester resident was its inventor and that it became a musical tradition in circuses and steamboats. Bill and Vanessa wanted the exhibit to incorporate a hands-on approach that would allow visitors to play musical notes from an actual calliope.

On April 3rd, a class of 3rd graders from May Street Elementary School took a school trip to WHM, exploring the entire museum. Wanting to see which aspects of the Fuller Gallery were most popular amongst this age group, we observed and interacted with them as they explored. In addition, on April 7th, we held a focus group with the same 3rd graders in their classroom, asking basic questions about what they liked and what they would like to see. Regarding the steam calliope, the 3rd graders seemed curious of the sound a calliope makes; they only commented to us that they want to hear a steam calliope performance to identify its sound.

Develop Design Criteria

While the project team was determining the aspects of the original steam calliope, we determined that an authentic playable steam calliope in a museum would be impossible; an authentic steam calliope requires complex mechanical components that cannot fit into any current galleries and operational costs that the staff cannot afford even for a short-term. In short, an authentic calliope does not match the feasibility requirements for the redesign. Among the project team members, we brainstormed alternative methods to present the steam calliope that would not involve the physical display of the steam calliope itself.

Two alternative redesign options we came up with included employing a computer application that could play audio tracks of steam calliope performances accompanied with video accompaniment, or a computer with a piano-style keyboard that could play a simulated digital steam calliope with all of its notes recorded. After presenting these ideas to the WHM staff, Vanessa Bumpus insisted that the redesign be subtle; the prototype must be simple, sanitary, and durable.

Additional interviews with Jeffrey Forgeng and Vincent Manzo helped determine specific criteria we needed to be aware of. Mr. Forgeng said that an interactive should simultaneously promote learning and fun to the visitors in a balanced manner; for instance, the exhibit should not deter the visitor from learning while having fun (and vice versa). The ideal learning environment for kids is a lively, fun environment. Kids will learn more if they can enjoy the learning process. Mr. Manzo relayed to us that an interface involving either buttons or a touchscreen fulfills the hands-on interactivity concept more effectively than a piano-style keyboard connected to a computer. In Boston Children's Museum's *Making America's Music*

exhibit, the interactive tools consisted of pads, toggles, and buttons to press to play songs, tunes, or sound effects, confirming Mr. Manzo’s statement.

Designs and Prototype of an Interactive Steam Calliope Exhibit

As noted in the design criteria section the Methodology chapter, we had to conceptualize a redesign that would meet all the feasibility requirements documented by the WHM staff. After countless hours of researching the pros and cons of each potential interface, we decided a touchscreen device would be the best option to choose for this exhibit. Further research consisted of finding the most appropriate application that would match the hands-on experience we hoped to achieve, such as virtual buttons or a virtual piano-style keyboard. We also had to find the appropriate tablet for our concept, which included the tablet’s ability to run the application we found out was the most optimal. We first researched mobile apps of music production as listed in Table 2, where we analyzed each available mobile app based on the crucial features listed in the top row. One additional feature we considered was the capability of the keyboard interface to cover the entire screen, so as to visibly remove all other features and buttons; the goal of this being to eliminate user distraction.

Mobile App	Manufacturer	Compatibility	Keyboard Interface?	Full-Screen Keyboard?	Adjustable Keyboard View?	Playback Feature?
SPC – Music Drum Pad	Mikrosonic	Android	Yes	No	No	Yes
FL Studio Mobile	Image-Line	Android & Apple	Yes	Yes	Yes	Yes
Cubasis	Steinberg	Android & Apple	Yes	Yes	Yes	Yes
Garageband	Apple	Apple	Yes	No	No	Yes
Sample Tank	IK Multimedia	Apple	Yes	No	No	Yes

Table 2: Music Production Mobile Apps Researched in Criteria

After compiling our information in Table 2, we honed in on application compatibility with Android or Apple model tablets. We researched the commercially available tablet brands in order to select the most compatible and feasible tablet for our prototype. We created a table (Table 3) of four tablets highlighting if each had the desired features for our design.

Tablet	Multi-Touch	8" or above?	App Lock?
Asus Transformer 101	Yes	Yes	Application-dependent
Galaxy Nexus	Yes	No	Application-dependent
Google Nexus 10	Yes	Yes	Application-dependent
iPad	Yes	No	Yes

Table 3: Tablet Computers Researched in Criteria

Our analysis of different tablets and their effectiveness, compatibility of apps, and the ability to lock apps allowed us to confidently conclude that an *iPad* best fit the concept we had in mind. Research of the musical instrument apps led to our selecting of *FL Studio Mobile*, a music production mobile app capable of loading recorded sound files to be played in its prebuilt virtual keyboard, as shown in Figure 19 below.



Figure 19: Virtual Keyboard from the mobile app *FL Studio Mobile* (Image-Line Software, 2013)

After we selected the software and hardware for the prototype design, we contacted institutions who have affiliations with existing steam calliopes to ask for note-by-note recordings. We found that the *Steamboat Natchez* from New Orleans was capable of providing us with performance recordings from their calliope. Debbie Fagnano, the current calliope player of the *Steamboat Natchez*, kindly recorded and sent us the recordings of each tuned whistle of the steam calliope for us to utilize in *FL Studio Mobile*.

On April 16th, we went to Seven Hills Charter School to conduct a focus group with one of the music teachers, Kathy Holton, and some of her students. We allowed the students to demonstrate with the app so we could get their feedback as well as Ms. Holton's. Kathy advised us to simplify the interface to only the keyboard view, provide visitors with sheet music of selected songs in musical letters (C D E F G A B), and provide an explanation of what tablet is simulating in the exhibit. Some students gave us the names of popular songs they would like to learn to play.

Evaluate Prototype and Refine

We incorporated our first prototype into the Fuller Gallery starting the week of April 22nd. The first audience consisted of important members of the WHM. As key donors to the museum, we wanted to receive their thoughts about how to make this as interesting as possible. After that, we continued evaluating our first prototype with families that were visiting the museum during the week. When the visitors used the steam calliope's prototype, we noticed that a majority of the visitors enjoyed the concept as a whole, and preferred to listen to either the sound of the notes or the songs. This encouraged us to search for simple popular children songs (for instance, nursery rhymes) and prepare sheet music such that any audience would

successfully play the song on the prototype. When we gave the visitors a chance to read the prepared sheet music and play (as shown in Appendix H), we found that they needed a moment to follow and tap their fingers to play the corresponding keys. The parents and the children who followed the sheet music and played a song enjoyed the opportunity.

Recommendations

Designing a case to fit the tablet while blocking other on-screen features

The tablet computer and the mobile app must only display a full-screen keyboard, meaning that the visitors must only view the keyboard and not the other figures/tabs as shown above the keyboard in Figure 19.

Employing an external loudspeaker

The tablet computer, even though it has a prebuilt speaker system, needs external loudspeakers to provide enough audio coverage to the visitors when using the steam calliope exhibit.

Playing audio files of performance recordings

The current full-screen keyboard in the touchscreen gives enough enjoyment of experiencing steam calliope, but this prototype would have benefitted some audio playbacks featuring actual performances of songs played on a steam calliope.

V. Conclusion

Our team focused on a redesign of the *In Their Shirtsleeves* exhibit in the Fuller Gallery of the Worcester Historical Museum. Specifically, we decided to pinpoint our efforts on three aspects within the exhibit itself. These were the David Clark Company Full-Pressure suit, Joshua Stoddard's steam calliope, and Worcester city directories that date back to the 19th century. During our seven weeks at the Worcester Historical Museum, we have developed our concepts and ideas to the point where the staff members at the museum, specifically Exhibitions Coordinator Vanessa Bumpus, can implement them into the exhibit. After much research pertaining to the design process and incorporating interactivity through museum exhibits, the project team was able to present the museum with the following three redesign aspects aimed to increase visitor interactivity.

With the David Clark Full-Pressure suit, we ultimately decided upon setting up green screen technology that would allow for visitors to see themselves in settings like the moon, satisfying the correlation between David Clark's suit and outer space. We came across the green screen technology on a trip to the Boson Children's Museum, where we found the inspiration in a simple, yet entertaining *Arthur* exhibit. A visit to a third grade class at the May Street School in Worcester, MA further cemented our belief that a green screen setup would interest the younger demographic that the museum brought in.

Ms. Vanessa Bumpus and Mr. Bill Wallace, our project sponsors, were adamant that we rectify the lack of information about the steam calliope. Specifically, they were very interested in creating the possibility to play notes or songs from a digital version of the Calliope. Due to space constraints, it was not feasible to try and find an actual calliope and put it into the gallery. Our research revealed a quality alternative. Installing a tablet with a

touchscreen keyboard that would play the different notes of a steam calliope became our goal. We discovered an app on the iPad, called *FL Studio Mobile*, which would allow the uploading of notes from another instrument. We had sounds from a steam calliope mailed to us from the *Steamboat Natchez*. Overall, *FL Studio Mobile* offers an attractive looking format that appeals to visitors, while helping people understand exactly what a steam calliope is.

Finally, when implementing the city directories into the gallery, we strived to find an effective method of making the content of the directories searchable. The museum receives many calls from people looking for information about a friend or a relative that lived in Worcester during a certain time period. Being able to search these directories on a computer would add an intrigue level for museum visitors while also supplying the museum staff with an easy-to-use interface that would allow for the simple search of a name in the directories. Rather than typing in the hundreds of thousands of names in each volume, we established that the easiest way to achieve our goal was to scan the pages into a computer and use OCR technology to make the words on each page searchable.

Bibliography

9/11 Memorial Guide. (2014). Retrieved Feb. 22, 2014, from <http://www.911memorial.org/911-memorial-guide>

Alexander, E. P., & Alexander, M. (2007). *Museums in Motion: An Introduction to the History and Functions of Museums*: Rowman Altamira.

American Association of Museums: Museum Facts. (2014). Retrieved Feb. 20, 2014, from <http://aam-us.org/about-museums/museum-facts>

Bitgood, S. (2006). An Analysis of Visitor Circulation: Movement Patterns and the General Value Principle. *Curator*, 49, 463 – 475

Borun, M., Chambers, M. B., Dritsas, J., & Johnson, J. I. (1997). Enhancing Family Learning Through Exhibits. *Curator: The Museum Journal*, 40(4), 279-295.

Canadian War Museum. (2014). *Special Exhibitions*. Retrieved Mar. 19, 2014, from <http://www.warmuseum.ca/exhibitions/special-exhibitions/>

Ciolfi, L., & Bannon, L. (2002). *Designing Interactive Museum Exhibits: Enhancing Visitor Curiosity Through Augmented Artefacts*.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *The Journal of the Learning Sciences*, 13(1), 15-42. doi: 10.2307/1466931

Dean, D. K. (1996). *Museum Exhibition*. London: Routledge.

Dede, C. (2005). Planning for Neomillennial Learning Styles. *EDUCAUSE Quarterly*, 28(1), 7-12.

- Falk, J. H., & Dierking, L. D. (2000). *Learning From Museums: Visitor Experiences and the Making of Meaning*: Altamira Press.
- Fleck, M., Frid, M., Kindberg, T., O'Brien-Strain, E., Rajani, R., & Spasojevic, M. (2002). From Informing to Remembering: Ubiquitous Systems in Interactive Museums. *IEEE Pervasive Computing*, 1(2), 13-21. doi: 10.1109/MPRV.2002.1012333
- Foster, J. (2010). *The Green Screen Handbook*: Sybex.
- Gallacher, C. A., & Treleven, D. E. (1988). Developing An Online Database and Printed Directory and Subject Guide to Oral History Collections. *The Oral History Review*, 16(1), 33-68. doi: 10.2307/3674808
- GAO. (2012). *Designing Evaluations*, GAO-11-646SP. Washington, D.C.
- Golding, D. (2014). Consultation with Dominic Golding.
- Hands-On Green Screen. (2013). Retrieved Mar. 20, 2014, from <http://www.handsongreenscreen.com/>
- HHM: Museum and Online Exhibitions. (2013). Retrieved Feb. 22, 2014, from <http://www.harborhistorymuseum.org/exhibits/>
- Hirsch-Kreinsen, H. (2008). "Low-Tech" Innovations. *Industry and Innovation*, 15(1), 19-43. doi: 10.1080/13662710701850691
- Hsi, S., & Fait, H. (2005). RFID Enhances Visitors' Museum Experience at the Exploratorium. *Communications of the ACM*, 48(9), 60-65.
- Interactivity. (2007) (pp. 563-613). Berkeley, CA: Apress.

- Johnson, A. (2013). The Solomon Northup Tour. Retrieved February 11, 2014
- Johnson, J. (2002). Families Exploring Science Together. *The Journal of Museum Education*, 27(2/3), 7-10. doi: 10.2307/40479250
- Karp, I., & Lavine, S. D. (1991). *Exhibiting Cultures*: Smithsonian Institution Press Washington, DC.
- Katz, P. (1995). The Quandaries of the Small Museum. *The Journal of Museum Education*, 20(1), 15-17. doi: 10.2307/40479486
- Kavanagh, G., Ebrary Academic, C., & ebrary, I. (2005). *Making Histories in Museums*. New York: Continuum International Publishing.
- Kotler, N. G., Kotler, P., & Kotler, W. I. (2008). *Museum Marketing and Strategy: Designing Missions, Building Audiences, Generating Revenue and Resources*: John Wiley & Sons.
- Kryder-Reid, E. (2006). *Shaping Outcomes*. Institute of Museum and Library Services. Washington, D.C.
- Laursen, D. (2013). Co-Participation Among School Children Around a Computer-Based Exhibit. *Social Studies of Science*, 43(1), 97-117. doi: 10.1177/0306312712455114
- Leinhardt, G., Knutson, K., & Crowley, K. (2003). Museum Learning Collaborative Redux. *The Journal of Museum Education*, 28(1), 23-31. doi: 10.2307/40479277
- Lord, B. (2007). *The Manual of Museum Learning* (B. Lord Ed.). Lanham, MD: AltaMira Press.
- Lord, B., & Lord, G. D. (2002). *The Manual of Museum Exhibitions*: Rowman Altamira.

- Macdonald, S. (2008). Visitors, Learning, Interacting. In S. Macdonald (Ed.), *A Companion to Museum Studies* (pp. 353-361). Malden, MA, USA: Blackwell Publishing Ltd.
- Majewski, J. (1996). *Smithsonian Guidelines for Accessible Exhibition Design*. Washington, DC: Smithsonian Institution Press.
- New York Historical Society: Museum & Library. (2013). *Audio & App Tours*. Retrieved Feb. 12, 2014, from <http://www.nyhistory.org/visit/audio-tours>
- Pastore, E. (2009). *The Future of Museums and Libraries: A Discussion Guide* (IMLS-2009-RES-02). Institute of Museum and Library Services. Washington, D.C.
- Rosenberg, T. J. (2011). History Museums and Social Cohesion: Building Identity, Bridging Communities, and Addressing Difficult Issues. *Peabody Journal of Education*, 86(2), 115-128. doi: 10.1080/0161956X.2011.561171
- Serrell, B. (1998). *Paying Attention: Visitors and Museum Exhibitions*. Washington, D.C.: American Association of Museums.
- Stevenson, A. (2010). *Oxford Dictionary of English* (3rd ed. / ed.). New York, NY: Oxford University Press,.
- Tohmo, T. (2004). Economic Value of a Local Museum: Factors of Willingness-to-Pay. *The Journal of Socio-Economics*, 33(2), 229-240. doi: <http://dx.doi.org/10.1016/j.socec.2003.12.012>
- Wallace, W. & Bumpus, V. (2014). First Sponsor Meeting.

- Wang, F., & Hannafin, M. J. (2005). Design-Based Research and Technology-Enhanced Learning Environments. *Educational Technology Research and Development*, 53(4), 5-23. doi: 10.2307/30221206
- Washburn, C. G. (1917). *Industrial Worcester*: Davis Press.
- WHM: Industrialization. (2013). Retrieved Feb. 2, 2014, from <http://www.worcesterhistory.org/worcesters-history/worcester-in-the-19th-century/industrialization/>
- Weil, S. E. (1990). *Rethinking the museum and other meditations*. Washington: Smithsonian Institution Press.
- Yaneva, A., Rabesandratana, T. M., & Greiner, B. (2009). Staging Scientific Controversies: A Gallery Test on Science Museums' Interactivity. *Public Understanding of Science (Bristol, England)*, 18(1), 79-90. doi: 10.1605/01.301-0005191506.2009
- Yiannoutsou, N., Papadimitriou, I., Komis, V., & Avouris, N. (2009). "Playing With" Museum Exhibits: Designing Educational Games Mediated by Mobile Technology.

Appendix A: Survey for Fuller Gallery (Adults)

We are a group of students from Worcester Polytechnic Institute working with the Worcester Historical Museum (WHM) on an interactive redesign of their Fuller Gallery and would be grateful for your input. Your participation in this survey is completely voluntary. All responses to this survey will be kept anonymous. If you would like your responses to remain confidential, please make a note at the end of the survey. If you would like to see the results of our research, please feel free to share your email address or contact us at whmd14@wpi.edu.

General Information

How many times have you visited Worcester Historical Museum over the last 2 years?

- First Time 1-2 3-5 5-10 More than 10

What precipitated your visit to the museum today? *(Please check all that apply)*

- Booth Gallery (*Worcester in the 1960s*) Fuller Gallery (*In Their Shirtsleeves*)
 Alden Family Gallery Rice Gallery (*Stories they Tell*)
 Entire Museum Library
 Other _____

If you are visiting with children today, how old are the children? *(Check all that apply)*

- Under 5 5 - 9 10 - 14
 15-18 Visiting Alone

What is your relationship to the child/children?

- Parent Grandparent Guardian
 Teacher Babysitter Other _____
-

Fuller Gallery Opinions

Our research is primarily focused in the Fuller Gallery (*In Their Shirtsleeves* exhibit)? If you visited that exhibit, was there anything you found particularly interesting about it?

Was there anything that you did not like, or that you would change, in the Fuller Gallery?

Additional Comments:

Full-Pressure Suit

Did you view the Full-Pressure Suit made by the David Clark Company?

Yes No

We are working on redesigning the Full-Pressure Suit exhibit; please rank your interest level of the following exhibit design ideas (1=least interested, 5=most interested):

___ Incorporating Green Screen technology to allow the visitor to see themselves in space

___ Showing videos of the space missions to the moon (i.e. Neil Armstrong's famous landing)

___ Incorporating a quiz that tests visitors' knowledge of space exploration

Steam Calliope

Did you view Joshua Stoddard's steam calliope displayed in the Fuller Gallery?

Yes No

If yes, please rank your level of interest in the following design ideas (1=least interested to 5=most interested):

___ Incorporating interactive keyboard that plays steam calliope notes

___ Incorporating an interactive touchscreen that allows visitors to hear a song played by a steam calliope

___ Displaying a small-replica model of a steam calliope for visitors to view

Worcester City Directories (1844-Present)

What type of technology are you most comfortable with? *(Check all that apply)*

- iPad/Tablet
- Desktop Computer
- Laptop Computer
- Touchscreen Computer
- Mobile Phones
- Other_____

Do you think you would use a searchable, computer-based collection of Worcester’s historical city records that date back to 1844?

- Yes
- No

Why or why not?

What would you be interested in searching the city records for? *(Check all that apply)*

- Research a family member or friend
- Research history of a particular address
- General Interest
- Interest in particular company
- Academic/General Research Purposes
- Other_____

Thank you for taking the time to complete this survey!

Appendix B: Questions for Fuller Gallery (Children)

We are a group of students from Worcester Polytechnic Institute working with the Worcester Historical Museum (WHM) on an interactive redesign of their Fuller Gallery. We designed these questions to solicit feedback from elementary school students regarding the interactivity of the Fuller Gallery. We are working to redesign key aspects of the Worcester Historical Museum's *In Their Shirtsleeves* exhibit. *In Their Shirtsleeves* highlights the unique and diverse industrial history of Worcester, exhibiting hundreds of artifacts and stories of industrial Worcester dating back to the 18th century. Our focus is on the David Clark Company's Full-Pressure, High Altitude Flying Suit and Joshua Stoddard's steam calliope, both invented here in Worcester. We will use your responses to help us determine sources of interactivity for these two artifacts. Your participation in this survey is completely voluntary. All your responses will be kept anonymous. If you would like your responses to remain confidential, please let us know.

All these questions will be based upon a yes or no answer (show of hands) or simple response questions.

What grade are you in?

Who enjoyed the *In Their Shirtsleeves* exhibit? (*Show of hands*)

What was your favorite artifact in the exhibit? (*Select students raising their hands*)

Who enjoyed the sound sticks that are spread across the exhibit? (*Show of hands*)

Who knows what a calliope sounds like? (*Show of hands*)

Who would like to be able to touch buttons to play and hear a calliope? (*Show of hands*)

Who knows the company that invented the large orange Full-Pressure Suit? (*Select students raising their hands*)

Who knows the name of the man who spoke through the headset next to the suit in space? Hint: He was the first man to walk on the moon. (*Select students raising their hands*)

Who would like to be able to see videos of people in space using similar suits? (*Show of hands*)

Who has seen a weatherman on the news? (*Show of hands*)

Who would like to be able to use this green screen technology to see themselves in space? (*Show of hands*)

Thank you for answering our questions. I hope you enjoyed/are enjoying the tour and I hope you learn something new about the city of Worcester today!

Appendix C: Survey for the Digitized Worcester City Directories

We are a group of students from Worcester Polytechnic Institute working with the Worcester Historical Museum (WHM) on an interactive redesign of their Fuller Gallery and would appreciate your input. Your participation in this survey is completely voluntary. All responses to this survey will be kept anonymous. If you would like to see the results of our research, please feel free to share your email address or to contact us at WHMd14@wpi.edu.

What did you use a database containing these public records for? (Check all that apply)

- Research a family member or friend
- General Interest
- Interest in particular company
- Academic/General Research Purposes
- Other _____

Did you use the search option in the top right corner of the screen?

- Yes
- No

If yes, did you find any faults with the search option?

- Yes
- No

If yes, can you explain the issue(s)?

Do you have any additional comments or suggestions to improve this digitized exhibit?

Thanks for your time! We hope you enjoy your experience at the Worcester Historical Museum!

Appendix D: Interview Questions for Marla Quinones

Interview with Mrs. Marla Quinones at Boston Children's Museum, March 19, 2014

The Worcester Historical Museum D-Term Team

Participants: Marla Quinones, Ali Fuat Becan, Matthew Harrington, Keith Lundgren, Kyle Orfan

1. When it comes to providing interactive exhibits catered towards drawing children, what are the design processes would you recommend us to tackle and design criteria we should be aware of?
2. What are some of the most important learning outcomes you would want children to take away?
3. Based on your experience with visitors, would an adult visitor take away learning outcomes when they visit a museum with their children or without their children? If so, what are the different outcomes?
4. Specially, when you helped Worcester Historical Museum redesign its Alden Gallery, what are the traditional design procedures/methods you went through to accomplish an interactive children's gallery? Could we pattern these methods for the Fuller Gallery?
5. What are the methods you are familiar with presenting an exhibit prototype? Would you suggest us the safest or feasible methods we could pattern?

Appendix E: Interview Questions for Vincent Manzo

Interview with Professor Vincent Manzo at Worcester Polytechnic Institute, 16:00 March 25, 2014

The Worcester Historical Museum D-Term Team

Participants: Vincent Manzo, Ali Fuat Becan, Keith Lundgren

1. If you were to present a musical instrument in a small museum without installing a physical replica of the instrument, what approaches would you take?
2. If we were to incorporate any technology, what kind of technology would you consider to employ to present musical instruments in a museum? A computer with physical buttons or multi-touch touchscreen?
3. What kinds of digital device applications or computer applications you would recommend us to research to create a music exhibit prototype?
4. Are there any other experts on music exhibits you could redirect us to in the future?

Appendix F: Interview Questions for Jeffrey Forgeng

Interview with Professor Jeffrey Forgeng at Worcester Polytechnic Institute, 14:00 March 28, 2014

The Worcester Historical Museum D-Term Team

Participants: Jeffrey Forgeng, Ali Fuat Becan, Keith Lundgren

1. Are visitors typically eager to interact with museum exhibits?
2. In your experience, do visitors tend to touch artifacts that have “do not touch” labels?
3. We are familiar with some of the interactive exhibits at Higgins Armory Museum, but can you tell us from your perspective about the important interactive exhibits from the armory museum, as well as the visitors’ responses to those exhibits?
4. How can a museum achieve a balance of learning and fun in an interactive exhibit? (i.e. trying on armor and using swords)
5. Can you explain the typical prototyping process for interactive exhibits?
6. From our visit with Marla Quinones at the BCM, we understand that interactivity requires a “reward” in order to be successful in exhibit design. Does this resonate with you? Did this factor into interactive exhibit designs at the Higgins? How can a museum go about determining an appropriate “reward” for a given interaction?
7. Is it more important for visitors to interact with the exhibits, or with other visitors in the museum? Is there a specific approach to creating a balance between the two?

Appendix G: Interview Questions for Diane Strong

Interview with Professor Diane Strong at Worcester Polytechnic Institute, 14:30 March 28, 2014

The Worcester Historical Museum D-Term Team

Participants: Diane Strong, Matthew Harrington, Kyle Orfan

1. Several museums, like the Carroll County Historical Society (Carroll County, Indiana) and the 9/11 Memorial and Museum utilize databases to organize certain public records. Is Microsoft Access the most functional system for creating such a database?
2. From our research, we believe that end-users of this database could benefit from seeing a scanned image of the page from the city directories. We have more than 100 volumes of directories. What kind of space constraints should we be aware of?
3. Our proposed database will require one member of the museum staff to update and manage the records. In your experience as a teacher, is Access a simple system to teach to system users?
4. Our project sponsor has an interest in creating a smartphone application that holds the same database and includes full search functionality. Have you worked with anything similar?
5. Is it feasible for our team to begin creating this database and educate the museum's system-users so that they may add to it when new city directories arrive at the museum? (New ones are published yearly)
6. We plan to display a prototype of the database for visitors to try. Are Access-based databases typically easy for the average visitor to use?

Appendix H: Interview Questions for Chris Catanese

Interview with Chris Catanese at New York Historical Society, 14:30 March 28, 2014

The Worcester Historical Museum D-Term Team

Participants: Chris Catanese, Ali Fuat Becan, Matthew Harrington, Kyle Orfan

1. In your experience with digitizing exhibits, what kinds of technologies are you in favor of using to exhibit collections?
2. To what extent should technology be incorporated to present the collections? What is your view on using portable computers against stationary computers?
3. What particular concerns did the NYHS have regarding the recent smartphone application?
4. Do visitors typically seek out exhibits that contain technology-based interactivity?
5. How willing are visitors to explore the technology in the exhibits?

Appendix I: Interview Questions for Jessica Colati

Interview with Jessica Colati from Worcester Polytechnic Institute, 13:00 April 7, 2014

The Worcester Historical Museum D-Term Team

Participants: Jessica Colati, Ali Fuat Becan, Matthew Harrington, Keith Lundgren, Kyle Orfan

1. How does WPI's Archives Department conduct the entire procedure of scanning fragile historic documents and directories?
2. Could you recommend any methods and precautions for the scanning of the city directories for our project?
3. When scanning the directories, how can we make the digitized directories be searchable? What available corporate software would you recommend us to transform these directories into flipbooks with sophisticated search engines?
4. What type of scanning equipment does the WPI Archives Department currently possess?
5. Are the Archives Department's resources (equipment, expertise, etc.) available to us for our IQP?

Appendix J: Interview Questions for Joy Hennig

Interview with Joy Hennig from Worcester Public Library, 17:00 April 8, 2014

The Worcester Historical Museum D-Term Team

Participants: Joy Hennig, Ali Fuat Becan, Matthew Harrington, Keith Lundgren, Kyle Orfan

1. The genealogy and local history collection at the library is quite large. Do casual visitors (those that are not looking for specific records) show strong interest in the collection?
2. Similar to the library at the WHM, many visitors search the records for something specific (a relative, famous figure, specific company, etc.). Are there any time periods or groups of people that are especially popular with guests?
3. Has the genealogy department considered any methods of digitizing city records (directories, census records, etc.)?
4. Would digitizing these records make them more accessible to visitors?
5. Would a digital collection of records help to make visitors more aware of the records contained in the museum and the library?

Appendix K: Methodology for Survey Approach

Administration of Survey

The successful evaluation of the progress on the *In Their Shirtsleeves* exhibit requires the input of museum visitors. Our team will gain visitor input via the administration of surveys. Team members will administer the surveys at the end of a guided tour of the museum, but visitors have the freedom to take the survey when they please. The surveys mentioned in Appendix II require the endorsement of an adult representative of the children that typically visit the Worcester Historical Museum. Students from local schools frequently visit the museum. There are students from ages 5 to 18, and those students younger than age 18 will need adult consent before completing the survey. Our team will also administer surveys to parents that agree to participate. These surveys are completely voluntary and offer the participant the option to remain completely anonymous. If the participant does not opt to remain anonymous, the WHM team may reveal their responses in a detailed report.

Our team will meet briefly in private with parents and/or teachers prior to administering surveys. The purpose of the meeting is to ask permission of the teachers for the survey distribution, as well as to describe the purpose of the survey and the museum redesign itself. The parents and teachers have complete discretion of when and where to administer the survey. If they feel most comfortable waiting to ask the children about the survey outside of the museum, whether at home or at school, they are welcome to do so.

Disclosure Statement

As previously mentioned, our team will require verbal consent from an adult representative in order to administer surveys to visitors under the age of 18. When approaching teachers, chaperones, and any other adult representative, our team will use a disclosure statement similar to the following:

We are a team of Worcester Polytechnic Institute students working with the Worcester Historical Museum. Our team will focus on a redesign of the *In Their Shirtsleeves* industrial history exhibit. We would like to ask that you distribute these surveys to your students in order for us to gauge visitor perception of the current state of the exhibit. These surveys are completely voluntary and the students may complete them whenever is convenient. Please notify students that they may choose to remain anonymous by selecting the option for anonymity at the end of the survey. Thank you for your time.

Purpose of Survey

This report will chronicle the visitor interactions with the new changes in the *In Their Shirtsleeves* exhibit in the Worcester Historical Museum. These responses will help the WHM team to determine the efficacy of the newly implemented changes in the museum. These surveys may appear at a number of different stages in the museum redesign process, and therefore will require a significant amount of data analysis. Personal information will bear absolutely no influence in the analysis of visitor responses, and is unnecessary in the survey.

Appendix L: Visitor Photograph/Video Consent

Acquisition of Photographs and Videos

During the course of our team's work at the Worcester Historical Museum there will be various opportunities for photo and video documentation of the progression of the exhibit redesign. These visual interpretations will serve as a resource to our group's continued efforts, and will function as diagrams and figures in the final report. These photographs and videos will contain a combination of various elements of the exhibits within the WHM and other similar museums. In each instance, there is a distinct possibility that the photograph or video may contain visitors engaging with the exhibits. In compliance with IRB standards and traditional confidentiality requirements, our team will request verbal and written consent from willing participants if they are visible in the photograph or video.

Disclosure Statement for Acquisition of Photographs and Videos

While acquiring photographs and videos in the *In Their Shirtsleeves* exhibit and exhibits within other museums, our team will use a disclosure statement with all visitors. Similar to the methodology listed in Appendix D for the survey methodology, we will request the consent of an adult guardian for all visitors under the age of 18. The disclosure statement will read as follows:

We are a team of Worcester Polytechnic Institute students working with the Worcester Historical Museum. Our team will focus on a redesign of the *In Their Shirtsleeves* industrial history exhibit. We would like to take a photograph and/or video depicting yourself and others interacting with the various exhibits within the museum. Your identity will remain completely anonymous if you choose, and your images will function only as an educational resource. Our team may scale, crop, or enhance your image, but will not alter the image in any other ways. Your participation is completely voluntary and you may ask any member of the team to withdraw your images at any time. If you are under the age of 18, you must obtain the consent of an adult guardian before participating. Thank you for your time.

Purpose of Photographs and Videos

The photographs and videos obtained during the course of our work at WHM will serve primarily as a resource for our team to chronicle visitor interaction in museum exhibits. This will prove especially helpful in the creation of our final report. These photographs will help the museum staff to visualize the impact of interactivity in museum exhibits and specifically how interactive exhibits help to engage visitors.

Appendix M: Photographic/ Media Consent Form



WPI

Photographic / Media Consent Form

We are a team of Worcester Polytechnic Institute students working with the Worcester Historical Museum. Our team will focus on a redesign of the *In Their Shirtsleeves* industrial history exhibit. We would like to take a photograph and/or video depicting yourself and others interacting with the various exhibits within the museum. Your identity will remain completely anonymous if you choose, and your images will function only as an educational resource. Our team may scale, crop, or enhance your image, but will not alter the image in any other ways. Your participation is completely voluntary and you may ask any member of the team to withdraw your images at any time. If you are under the age of 18, you must obtain the consent of an adult guardian before participating. Thank you for your time.

I hereby consent to the collection and use of my personal images via photography or video recording.

I acknowledge these may appear on the Worcester Community Project Center website, in newsletters and publications as well as distributed to members.

I understand that no personal information, such as names, will appear in any publications unless I give express written consent.

I acknowledge that the members of the Worcester Historical Museum Redesign team may scale, crop, or enhance images or recordings of myself and others, but they will not alter the images or recordings in any other way.

I also understand that I may withdraw this consent anytime, upon written notice to the members of the Worcester Historical Museum Redesign team via e-mail.

CONSENT FORM

I
Name of person giving consent & parent/guardian if under 18 years of age

Voluntarily consent to the use of photographs or video footage for use on the final report and records of the Worcester Historical Museum Redesign team, as well as the Worcester Community Project Center website.

I further understand that I may withdraw this consent anytime, upon written notice.

.....
Signature of person giving consent

.....
Signature of parent/guardian < 18

Date

Appendix N: Learning Outcomes Survey for Teachers

Worcester Historical Museum – *In Their Shirtsleeves* Learning Outcomes Survey

We are a group of students from Worcester Polytechnic Institute working with the Worcester Historical Museum (WHM) on an interactive redesign of the Fuller Gallery. We designed this survey to cultivate feedback from elementary school teachers regarding learning outcomes in museum exhibits. In an ongoing redesign process in the *In Their Shirtsleeves* exhibit of the Worcester Historical Museum, we plan to redesign key aspects of the exhibit, including David Clark Company's Full-Pressure, High Altitude Flying Suit and Joshua Stoddard's steam calliope, both invented here in Worcester. We intend to use these responses to aid in determining the learning outcomes of these two artifacts in our redesign. Participation in this survey is completely voluntary. Your responses will be kept anonymous if desired. If you would like your responses to remain confidential, please make a note at the end of the survey.

1. How many times have you visited the Worcester Historical Museum?

- Never 2-4 times 5-7 times 7-10 times
 More than 10 times

If you have visited the museum, what were you and/or your students' favorite aspect/part of the museum?

2. When you bring your students on a field trip to a museum or similar institution, how much information do you think that the exhibits should convey to visitors? Do you think that students may become overwhelmed or disinterested if the exhibit presents too much information?

3. In your experience, what aspects of a museum exhibit help students learn the most? (ex. Pictures, sounds, staff interaction, etc.)

4. Regarding David Clark Company's Full-Pressure flying suit, what would you like most for it to teach you and your students? For example, would you prefer it to connect to NASA and the famous moon landing of 1969 or focus more on the story behind how the suit was invented?

5. Regarding Joshua Stoddard's steam calliope, which is a musical instrument similar to the organ used on steamships in the 19th century, what would appeal to you and your student's the most: The sounds the calliope makes or the physical appearance of it?

Appendix O: Sheet Music for Calliope Prototype

The sheet music provided in letters below are for the visitors (children and parents included) to attempt to play some of the simple songs on the keyboard interface of the steam calliope exhibit as exhibited in Figure 19.

Hot Cross Buns – 1798 (EASY)

Start here →

Start	B4				B4			
		A4				A4		
			G4				G4	
				B4				E N D
		A4	A4		A4			
G4	G4					G4		

→ End

Twinkle, Twinkle Little Star - 1761 (Trad. French melody) & 1806 - Jane Taylor (MEDIUM)

4				A4	A4									
			G4	G4			G4							
								F4	F4					
										E4	E4			
												D4	D4	
	C4	C4											C4	

4														F
	G4	G4						G4	G4					I
			F4	F4						F4	F4			N
					E4	E4						E4	E4	I
							D4						D4	S
													H	