Bennett Place AR: Evaluating an AR Application at a Historic Site from a UX Perspective

by

Ruojin Shi

Department of Art, Art History and Visual Studies
Duke University

Defense Date: November 27, 2023

Approved:

Victoria Szabo, Supervisor
Augustus Wendell
Edward Triplett

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Art, Art History and Visual Studies in The Graduate School of Duke University
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ABSTRACT

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Abstract

This thesis explores the integration of User Experience (UX) Design in digital humanities, with a focus on Augmented Reality (AR) at Bennett Place. It draws on Brennan's public digital humanity concept, emphasizing the need for public-oriented approaches in digital humanities. The research employs UX design methods, adhering to a workflow comprising research, ideation, design, and user testing.

In the research stage, Bennett Place's historical context and visitor personas are analyzed to inform design objectives and user expectations. The ideation stage addresses content design and AR technology selection, aiming for effective information delivery and inclusive user experiences. The design stage details the digital project's implementation. The final delivery of this thesis is an iOS AR application. The final stage involves user testing to evaluate the application of AR in enhancing on-site visiting experience at Bennett Place.

Although the testing results are not definitive, they provide valuable insights for future digital humanities projects, particularly in public engagement. This thesis demonstrates the effectiveness of AR in enhancing on-site visiting experience at Bennett Place and highlights the potential for incorporating UX methodologies in digital humanities, advocating for more user-focused, engaging, and informative experiences.
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1. Introduction

1.1 Augmented Reality and Public Digital Humanities

Augmented Reality (AR) is a technology that merges computer-generated content into a live view of the physical world, creating a mixed reality.\(^1\) This augmentation occurs in real time and is contextually connected with environmental elements. AR converts real-world information into an interactive digital interface, making it accessible and manipulable. However, AR transcends its technological framework; it serves as a conduit for communication and interaction among humans, and between computers and humans. In essence, AR is a medium where information is seamlessly infused into the physical world. Just as humans interact with different media in different ways, for example people “read” books and “watch” movies, AR provides an experience that users can “engage” with.\(^2\)

This perspective of AR as a medium expands the exploration of AR’s applications beyond the scope of technologies. While its technological novelty makes AR intrinsically engaging, AR’s intrinsic value is accentuated when applied to specific problems or areas like education, art, military, or entertainment. Its potency lies in its capacity to address real-world problems or enhance experiences. Some of key affordances of AR is that the AR experience takes place in the real world, at a specific place at a specific time. Exploiting these affordances in a positive way to solve a problem or enhance experience makes AR a good candidate to be applied in one field.\(^3\)

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3 Craig, *Understanding Augmented Reality*, 222.
In the context of public digital humanities, AR can be a promising tool to provide a distinctive experience at historic sites due to its distinctive affordances. While traditional methods of obtaining historical and humanistic information, such as reading books or visiting websites, offer value, AR can support public digital humanities by enhancing the on-site visiting experience at historic sites. To be more specific, AR can juxtapose the past with present realities by adding a virtual layer of information about the past at a historic site to the physical environment. It allows users to explore the site with gears or their mobile devices, through which they can easily access historic records, like past photos or sketches, of the site. In some cases, if some of the original objects or structures are destroyed or lost, digitally reconstructed models can be placed at the same location or overlay with the original objects, juxtaposing the past with the present through the AR experience. This juxtaposition improves the user’s spatial understanding by helping visitors relate historic information to the physical space around them and allows the user to appreciate and witness the transformation of the site.

In addition, AR can boost historic information comprehension in the on-site visiting experience of historic sites. Certainly, visitors at historic sites can access historic information and knowledge through their museums, galleries, guided tours, and labels. The level to which they can comprehend historic information and knowledge about the sites can be elevated by AR experience. Previous research done by Harley et al. has proved that their AR application for the historic site at the Roddick Gates can support the student’s understanding of historical landmarks.4 AR can integrate multi-media digital content, including text, video, audio, 3D models and animations, to effectively convey historic information and knowledge to the users.

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AR transforms the abstract or complex history into images, audios or videos that include expert insights and explanations about the history and encourages exploration and learning of historic sites through gamification techniques, like reward systems or interactive games. In this way, historic sites can transform the conventional informative displays into interactive, immersive, and engaging learning journeys, making history more alive and tangible to the public and ensuring that visitors not only receive information but also comprehend the history.

AR can also play a pivotal role in evoking empathy, fostering a sense of community, empowerment, pride, or reflection at historic sites. AR can present the history with immersive storytelling techniques to the public. Visual augmentations of 3D models, animations, and visual effects allows AR to bring history to life, enabling visitors to visualize the historic sites in its prime. Narration is another strategy to tell untold stories and histories from a humanistic perspective, including the lives of individuals and communities at that period. Following the humanistic narrative about the historic site, AR can transport visitors back in time, allowing them to feel, understand, and connect with history on a profound level. AR is a tool not just for education but for emotional and social engagement. This enriched, personalized, and interactive experience fosters empathy, a sense of community, empowerment, and pride among visitors, making the historical site a living entity echoing the tales of the past, and fostering a deeper human connection.

In conclusion, the exploration of AR’s application in public history, particularly at historical sites, is of paramount importance. AR transcends traditional informational displays, offering an enriched, immersive, and engaging on-site experience, making history more palpable and resonant to the public.
1.2 Durham as a Case Study

Durham, a city in North Carolina, has a rich and complex history, notably marked by its significant role in the mid-19th century and the Civil War era. The city was established during a chaotic time of war and reconstruction and played a pivotal role in historical events. The origin of Durham can be traced back to land transactions and developments in the mid-1800s, with figures like Dr. Bartlett L. Durham who played crucial roles in its establishment.\textsuperscript{5}

The Civil War left an indelible mark in Durham. The city was a neutral ground during the truce, a place where soldiers from both the Union and the Confederacy rested. The Bennitt farmhouse, also known as the Bennett farmhouse, situated west of Durham, was a pivotal site for peace negotiations and surrender, signaling the war's conclusion.\textsuperscript{5} Durham also became renowned for its tobacco during this era. As the war ended, Union soldiers carried stories of Durham's unique tobacco back home, promoting the Durham's bright-leaf tobacco national wide.\textsuperscript{7}

Moreover, the city was home to notable figures at that time, such as Washington Duke, the founder of tobacco manufacturer, W. Duke, Sons & Co. Under the leadership of his son, James B. Duke, it eventually merged with other companies to form the famous American Tobacco Company.\textsuperscript{8}

Today, Durham stands as a living testament to its intricate past, inviting exploration and reflection. The city is a rich mosaic of history, where the preserved buildings, monuments, and historic sites became vibrant sources of insights, stories and experiences and became the inspiration and grounding of this thesis project. They offer tangible opportunities to delve into the

\textsuperscript{6} Anderson, Durham County, 104.
\textsuperscript{7} Anderson, Durham County, 106.
19th century that have not only shaped the city but also influenced the nation. The application of AR in Durham promises an immersive journey where the past and present converge.

1.3 Thesis Statement and Overview

This thesis project aims to explore the application of Augmented Reality in the public digital humanities field in enhancing the on-site visiting experience of historic sites. This project uses Durham and one of its historic sites, Bennett Place, as a case study due to their distinctive historic value to the local community and their accessibility during the development of this thesis project. This project will evaluate the effectiveness of AR’s application, with special focus on the design of digital content and choice of AR tracking technology, in a public digital humanity project from a user experience design perspective.

The first chapter of this thesis introduces augmented reality’s application in the public digital humanity field and explains why Durham is selected as a case study in this project. The second chapter reviews previous concepts and theories related to this thesis project around public history, digital humanity and public digital humanity that emphasizes the role of the user and the necessity of including UX design techniques in digital humanity projects. Chapter three explains the idea of UX design and how this thesis project will include UX design ideas in the development and evaluation of the AR project. Chapter four is description of detailed design and implementation process, following a UX design flow. Chapter five discusses implications, limitations, and future directions of this thesis project. The last chapter summarizes the entire thesis and provides insights for implications of this thesis.
2. Related Concepts and Projects

2.1 Public History, Digital Humanities, and Public Digital Humanities

Public history has been an area of focus among scholars for several decades, with various perspectives and discussions on the topic. Robert Kelley explored the definition and importance of public history as the use of historians and the historical method outside academia. ¹ Kelley emphasized that public history is critical in bringing in the dimension of time to resolve issues, form policies, and plan activities more effectively and efficiently. David Glassberg discussed the importance of public history in shaping our collective memory and highlighted the ways in which public history can help us understand our past and present and create a more just and equitable future. ² He argued that public history should be considered a coherent subject of study, and he provides examples of successful public history projects that have impacted their communities. Michael Frisch acknowledged Glassberg's ideas on public history and memory studies but suggested that there is more work to be done in exploring the relationship between the two. ³ He highlighted the value of studying and preserving history for the public and how it can contribute to scholarship and audience research. Frisch emphasized the rich potential of public history and its role in shaping our understanding of the past.

Hayles referred to the digital humanities as emerging fields that utilize digital technologies to transform research, teaching, and publication in the humanities. ⁴ However, Sheila

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Brennan proposed that digital humanities can be “public.” Brennan provided an overview of the concepts of public history and digital humanities and their intersection in the field of “public digital humanities.” Brennan stated that digital humanities scholars and practitioners are distinguished from other humanities scholars by “digital,” while the “public” is what defines public historians and public humanities scholars. Brennan also pointed out that publishing research available online does not inherently make it public digital humanities. Instead, it’s critical to identify audiences outside the academy, understand their interests, lives, agendas, and challenges, and incorporate their voices in the early stages of public digital projects. Borrowing techniques from user-centric design and creating user personas might be helpful in creating a successful public digital humanities project.

Researchers have proposed expanding public history projects while highlighting how they impact communities. Focusing on public history projects creates tangible benefits for communities at a local level. It inspires key grassroots leaders to focus on long-term projects that positively impact current and future generations. Researchers have also addressed the link between memory studies and public history. They have observed that exploring public history creates opportunities for inter-communal collaboration. It showcases the possibilities that public projects attract, such as better relationships within and between communities. In addition to exploring opportunities for studying and preserving public history, it is necessary to ensure that all findings are publicly accessible. Brennan's proposal for openness and publicity should be

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considered since research outcomes are meant to be consumed by the public, not limited to the scholars.

Digital humanities introduce a new dimension to public history. They challenge the incorrect notion that humanities are incompatible with technological advancements. Digital humanities involve using computing devices and peripherals to revolutionize public history research. The concept also covers additional aspects of the research by defining the processes to publish and disseminate study findings. Integrating digital techniques, tools, and processes with traditional humanities impacts how scholars and the general public analyze and understand communication about public history. Public digital humanities are an intersection between two important fields and knowledge areas. It represents the opportunity to leverage digital technology's efficiency and cost savings with public history's popularity and emotional appeal. It makes public history widely and easily accessible to mainstream audiences, fulfilling Brennan's proposal.

Scholars and history studies practitioners are critical in the development of digital humanities. They are responsible for defining the parameters which facilitate the creation and implementation of the intersection. The widespread popularity of personalized computing means that such consultants' researchers can easily reach audiences worldwide. Technologies like smartphones and personal computers mean the public can readily engage with findings from multiple disciplines, including the humanities. By sharing findings on public history with a wider global audience, researchers will have a platform for collecting feedback. They may gather

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information on the significance of public history, technological challenges facing digital humanities, and key ethical concerns. Publishing public history findings will require a concise understanding of the diversity of the audience. Scholars and practitioners must develop ways of dealing with the sensitivities of historical events. The exercises will demonstrate how technology can merge with domain knowledge inclusively and respectfully.

Investigators should anticipate challenges to the implementation of public digital humanities. It is necessary to distinguish between true public engagement and online availability. The first step toward achieving the digital humanities goal is to ensure that all public history findings are published on the open web. The second step is ensuring that the content resonates with the public meaningfully. Efforts to sanitize or censor public history findings will undermine the rationale for open publication, leading to distrust. Identifying audiences for public history findings outside academia can be challenging due to socio-political divisions. However, scholars are tasked with finding ways to handle this obstacle, as bringing public history to people's consciences may address the internalized disagreements. It may be necessary to tailor various findings to the sensitivities of different communities and groups to facilitate effective dissemination and engagement. Fine-tuning findings to address specific communities requires scholars to actively investigate interests, preferences, and needs. They must shift their presentation from an academic-centric approach to end user-centrism.

The central task in digital humanities is defining a middle ground that ensures the message is not altered or diluted across communities or audiences. People's experiences, needs,

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and challenges often determine their perception of the past, present, and future.\textsuperscript{11} As such, the same event may trigger different emotions in audiences depending on their collective memory.\textsuperscript{12} The challenge of balancing accuracy with sensitivity can be addressed using the technological element of digital humanities. For example, scholars can use advanced software to tweak the delivery of historical findings. The solution considers technology's ability to duplicate content that creates customized solutions for different audiences. It also creates an opportunity for integrity of user voices in digital humanities. An excellent way to achieve this goal is by creating user personas representing target audiences with unique cultural or normative characteristics.

\textbf{2.2 Similar Projects}

\textbf{2.1.1 Durham Digital Archive}

The "Digital Durham" project offers a comprehensive look into the history of Durham, North Carolina, from the late nineteenth to the early twentieth century. Serving as a center for scholars, students, and educators, the website provides primary sources about Durham's economic, social, cultural, and political evolution during the era after the Civil War.\textsuperscript{13} The collection encompasses over 600 topics and provides access to a diverse range of manuscript and printed materials spanning from the 1870s to the 1920s.\textsuperscript{14} Additionally, the site offers a unique collection of maps depicting Durham from the late 1860s onwards. Educators can also benefit

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\textsuperscript{14} Abel, “Digital Durham.”
from specialized resources, including a glossary of terms from the 1880 census and lesson plans that align with the North Carolina Standard Course of Study.

The "Digital Durham" project shows the transformative power of digital humanities that successfully blends traditional academic disciplines with modern technological tools. It champions interdisciplinary collaboration by merging historical research with digital platforms and offers a more expansive exploration of Durham's past. A crucial aspect of digital humanities is the accessibility. "Digital Durham" exemplifies this by making historical content widely accessible, breaking down barriers that might limit scholarly engagement. Furthermore, the project harnesses technology for data analysis and visualization, allowing users to discern historical trends and patterns through interactive census data. Additionally, in the digital age, the importance of preservation cannot be overstated. "Digital Durham" ensures the longevity of invaluable historical resources from the 1870s to the 1920s by digitizing and archiving them, safeguarding our shared heritage for future generations.

While the primary focus of this project is to provide a database for researchers, educators and students, its further application also contributes to Durham community by including community engagement. In 2001, Dr. Abel, alongside student researchers from Duke University, initiated the beta-version of the Digital Durham website, showcasing an 1880 census database and selecting primary documents.15 By 2005, Duke University's Rare Book, Manuscript, and Special Collections Library expanded the site, resulting in over 1000 digitized images from various sources by the Digital Production Center at Perkins Library. The Web Solutions Team of Arts & Sciences Information Science and Technology and a local web development company, Hueism Inc., created a new website with a search function for this project. A team of graduate students at

15 Abel, “Digital Durham.”
Duke University worked with Kathy Wisser from NC ECHO and Dr. Abel on TEI transcriptions of the manuscript letters. The inclusion of a wide range of local communities emphasizes the inclusive involvement of diverse Durham community members in the project development. Additionally, this project’s power of community engagement also extends outside academia. In an undergraduate research seminar called “Digital Durham and the New South” that is designed based on this project, Duke University students collaborate with students from a local middle school to investigate the experience of youth who lived in late 19th-century Durham. The project bridges the gap between the university and the local Durham community. By involving middle-school students in collaborative learning experiences with university students, it fosters a sense of shared history between different age groups and educational backgrounds.

2.1.2 Durham Civil Rights Heritage Project

Launched in May 2003, the Durham Civil Rights Heritage Project (DCRHP) embarked on a mission to capture Durham's Civil Rights Movement through photographs and oral histories. Hosting collection events at locations like the Durham County Library, Hayti Heritage Center, and St. Joseph's AME Church, the initiative amassed roughly 12,530 images and documented 16 firsthand accounts. These resources were artistically repurposed into 11 large banners featuring photographs, quotes, and narratives, which toured various locations for over a decade and are now housed in the Stanford L. Warren Library. In 2008, an online exhibit was designed to make this project more widely accessible. This project provides the Durham community with a tangible

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resource, including photographs and oral history, to understand its own history in the context of the Civil Rights Movement. Durham community can gain a deeper appreciation for the struggles, triumphs, and contributions of their predecessors.

Triggered by the tragic events surrounding George Floyd and many others, in 2020, Savas Lab reached out to Durham County Library, one of sponsors of this project, in hopes to contribute to this project by redesigning and uplifting the original online exhibition that highlights Durham’s role in the Civil Rights Movement.\(^{18}\) The involvement of Savas Lab in enhancing the Durham Civil Rights Heritage website indicates a commitment to social responsibility and an alignment with the broader societal call for racial justice.

Now, with the work of teams from Durham County Library and Savas Lab, the original staid and inaccessible exhibit was transformed into an engaging website with image galleries and a responsive and animated timeline.\(^ {19}\) The Durham Civil Rights Heritage project website not only explores oral stories and photographs from key moments in the civil rights struggle in Durham, but also makes this project into a continuous dialogue. The project’s update in response to contemporary events signifies that the narrative of civil rights is evolving. At the same time, this project is open to more contributions to the collection from its community. This can lead to continuous community dialogues about present-day issues, ensuring that history doesn’t remain static and disconnected from current realities.


In essence, the Durham Civil Rights Heritage Project serves as a beacon of collective memory, education, and reflection, underlining the interwoven fabric of Durham's past, present, and future within the larger context of civil rights history.

2.1.3 Experiencing Civil War History Through Augmented Reality

The Virginia Center for Civil War Studies has initiated an Augmented Reality project, "Experiencing Civil War History Through Augmented Reality" for Pamplin Historical Park in Petersburg, Virginia (see fig.1). It is backed by the National Endowment for the Humanities. The Pamplin Historical Park, boasting four museums, three historic homes, and the Breakthrough Battlefield, stands as a key educational center for Civil War insights.²⁰

This project stands out in its approach to intertwining the Civil War narrative with four distinct humanities themes.²¹ The four humanities themes highlight the symbiotic relationship between the environment and wartime experiences, emphasizing how natural factors influenced military strategies and soldiers' well-being and portray households as microcosms of broader societal conflicts, especially those centered on race and gender. These themes also underscore the multifaceted roles of the Civil War, both opportunities and hardships, for enslaved African Americans. Lastly, they emphasize the importance of context in historical interpretation and aim to present critically analyzing historical sources to visitors in an interactive way to deepen their understanding of the past. With the four humanities themes as guidance, this project selects its storytelling strategies, including mediums used and historic information presented, that fit and support the humanities themes. For example, this project proposes to use AR video clips to depict

²¹ “Experiencing Civil War History through Augmented Reality.”
a household, Tudor Hall, as a place of social conflict and transformation, showcasing perspectives from its owners to enslaved individuals and wartime officers. Using this strategy, this project develops a clear format of the whole AR experience. Three sites inside Pamplin Historical Park are selected, each with key components in alignment with the four humanities themes.

While this project has not been published yet, its incorporation of the four humanities themes is pivotal in crafting compelling and informed narratives about Civil War history within an Augmented Reality (AR) framework. By integrating these themes, this AR project, Experiencing Civil War Through Augmented Reality, can offer a multi-dimensional understanding that resonates with the depth and complexity of the era. Furthermore, when designing an AR experience for a historic site, it's crucial to structure and format the content in a way that aligns seamlessly with the site's historical context. This not only ensures authenticity but also enhances user immersion, enabling visitors to connect more deeply with the historical narratives presented.

2.1.4 Once upon a Time in Dispilio & Crime in the Lake Settlement

University of Western Macedonia and Environmental Education Center of Kastoria have recently done a study about location-based Augmented Reality applications at a cultural heritage site, the prehistoric lake settlement of Dispilio. The research team presented two location-based AR applications, “Once upon a Time in Dispilio” and “Crime in the Lake Settlement,” that utilize gamification and storytelling to provide cultural heritage knowledge. Previous studies have shown that gamification and storytelling are two efficient methods for increasing learners’

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22 “Experiencing Civil War History through Augmented Reality.”
23 “Experiencing Civil War History through Augmented Reality.”
motivation, engagement, and satisfaction, especially for younger audiences. Therefore, the research team decided to develop two distinct location-based AR applications that use different techniques: an informative app “Once upon a Time in Dispilio” containing gamification elements and a storytelling experience “Crime in the Lake Settlement” (see fig.2 -fig.3).

In the informative app, “Once upon a Time in Dispilio,” users are guided by a map to reach designated locations marked by red dots and activate digital content (see fig.4). At each spot, users will be asked to answer multiple choice questions related to the settlement’s history, human activities and artifacts (see fig.5). These questions can be answered by observing surrounding environments, making the learning experience intuitive. Correct answers reward users with points and puzzle pieces, contributing to the completion of an image puzzle and offering immediate gratification (see fig.6). Then, historical information, mainly in the form of text, image and sound, will be presented to users as feedback. “Once upon a Time in Dispilio”, by combining gamification elements with informative and educational content about Dispilio, keeps the focus of the users on the archeological site and ensures an engaging learning experience. In the second project, “Crime in the Lake Settlement,” users become Inspector Solve, a character tasked with solving a captivating crime mystery (see fig.7). Unlike “Once upon a Time in Dispilio,” which focuses on direct educational engagement, this app employs storytelling to immerse users in historical context. Each clue and question is intricately woven into the narrative, allowing users to explore Dispilio’s past while navigating the crime mystery. The narrative approach not only enriches the learning experience but also distinguishes it from the more

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conventional educational style, offering users an adventurous and educational exploration of history.

In addition to its employment of gamification and storytelling methods in location-based AR applications, this study also provides valuable insights into the design and implementation process of AR applications. This study presents a comprehensive procedure of developing AR applications, including identifying target audience, selecting digital platforms, designing digital content, and evaluating the final outcomes. These insights serve as practical guides for educators and developers aiming to create immersive and educational AR applications.

2.1.5 Implications of Similar Projects

This thesis section reviews four related digital projects, examining their development, applications, methodologies, and design techniques. These digital projects offer invaluable insights in shaping the direction of this thesis.

The initial two projects are rooted in Durham and have obtained significant community attention, promoting broad community involvement. The Digital Durham archive is a collaborative effort, with various organizations and groups contributing, and becomes a database for researchers interested in Durham history. Its reach extends beyond academia, aiding local educational programs. The Durham Civil Rights Heritage project, on the other hand, digitizes original exhibitions and artworks, making them accessible to the local populace. The collaboration with the local company, Savas Lab, underscores the project's community resonance and its role in highlighting the Civil Rights Movement. This showcases the profound influence of public digital humanities projects on the Durham community. Both projects highlight the

26 Kleftodimos, Moustaka, and Evagelou, “Location-Based Augmented Reality”, 1.
potential of digital projects in making history accessible, fostering community engagement, and spotlighting local narratives. These two local projects suggest that by making history widely accessible to the public, digital humanities projects can serve the community and raise community attention and engagement. This provides insights about the value of this thesis project to the local community. By enhancing the visiting experience at Bennett Place in Durham, this thesis project can make this history more accessible to the public, not only fostering more attention to not only the rich history of Bennett Place but also serving the community by engaging more visitors.

The latter two projects are selected for their relevance to AR. The Experiencing Civil War History Through Augmented Reality project combines Civil War history with four humanistic themes via AR. This innovation proposal offers a blueprint for narrative construction and information organization within AR experiences in this thesis project. The projects Once Upon a Time in Dispilio and Crime in the Lake Settlement exemplify the integration of gamification and storytelling in AR. They offer a holistic view of AR application design, shedding light on the combination of diverse digital resources and strategies to heighten user engagement. Collectively, these projects provide a comprehensive understanding of AR's potential in historical and humanistic contexts, guiding the direction and objectives of this thesis.
3. From a User Experience Perspective

As noted in the previous discussion, Brennen proposed that borrowing design techniques from user experience design will be beneficial to public digital humanity projects. With this idea in mind, this project will follow a user experience design procedure and evaluate application of Augmented Reality in enhancing the on-site visiting experience at a historic site from a user experience design perspective.

3.1 UX Design Definition and History

UX design, or user experience design, entails developing user-focused digital services and products that give consumers desired experiences. According to Davidaviien et al., UX design entails understanding user needs and behaviors, creating user-friendly interfaces, and testing and refining designs to make sure they satisfy clients’ expectations.¹ The article argues that UX design aims to make products that are easy to use, effective, attractive, and enjoyable to the target users. The evolution of UX design traces back to the early years of computer technology, where the focus was predominantly on enhancing the functionality and usability of hardware and software.² By the late 20th century, with the rise of more complex technologies, there was a pivotal shift in the field: professionals began to prioritize the overall user experience, integrating user-centered design principles. This marked a significant transition from a purely technical outlook to a more holistic approach that incorporates the user's perspective and needs in design processes. In the 1980s, Don Norman created the phrase “user experience” when he was

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employed by Apple Computers, initially focusing on non-networked desktop systems. He stressed how crucial it was to create items that were useful and appealing to the eye of the customer, with easy-to-use features. As the internet evolved, user experience expanded to include web design, adapting to changes like the shift to mobile interfaces and the integration of AI in Web 3.0, reflecting the adaptation of user experience principles to various technological advancements, from desktop computing to the dynamic, interconnected digital landscape of today. Bellalouna states that UX design is becoming a crucial step while creating new products for businesses across all sectors. Designers must continue innovating and adapting their methods and devices to meet the evolving needs of users, especially with the rise in mobile device features and other new technologies, to ensure people can access, understand, and enjoy digital products.

Moreover, Robinson et al. discuss the development and history of user experience research and its today’s position and future paths. The authors examine numerous research techniques and tools used in UX design, such as user testing, surveys, and analytics, as well as the current state of UX research and its potential future paths. The research emphasizes the need of empirical study in UX design and how it has changed through time to accommodate users’ dynamic needs. Moreover, the authors outline the difficulties UX researchers have encountered to accommodate the evolving needs of user experience design and offer advice on addressing such issues, including knowing how to conduct consumer need analysis. The article highlights the value of interdisciplinary collaboration to make UX research inclusive and available to all users. Overall, the paper offers a thorough overview of the past, present, and potential future of

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empirical research in user experience and serves as an invaluable resource for UX researchers, designers, and practitioners.

3.2 **UX Design Flow in AR Projects**

UX Design Flow refers to the sequence of activities or steps in the process of designing user experiences for digital products, like websites, applications, or software and often includes several stages that focus on understanding user needs, designing corresponding solutions, and refining these solutions based on user feedback and testing. Establishing an effective UX design flow is paramount in project development. While the UX design industry adheres to a standard flow, the realm of AR projects lacks a universally accepted norm. Previous studies on UX design in AR projects have offered diverse approaches. For instance, Robinson et al. explore UX research methodology's evolution, paralleling AR design. They emphasize dynamic research, noting varied approaches such as usability studies, surveys, interviews, and quantitative methods. Keating et al. present a three-step adaptation tailored to address challenges in integrating graphics within the 3D camera view. Their process commences with pass-through paper prototypes, advances to 2D data emulation within a 3D context, and concludes with the creation of physical 3D models. This method provides a multifaceted perspective, effectively uncovering design issues.

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Meanwhile, Al Ghanmi et al. champion the integration of Scrum\textsuperscript{7} into AR UX design, ensuring seamless harmony between development and user experience alignment.\textsuperscript{8} Their viable framework for AR UX design flow unfolds through a structured sequence of four stages that complement and reinforce one another (see fig. 8). Commencing with ‘User Research’, a comprehensive exploration of users' behaviors, needs, and preferences takes place, thereby establishing a robust foundation for subsequent design decisions. Subsequently, ‘Wireframing and Ideation’ harnesses the insights garnered from user research to generate a multitude of innovative ideas. The ensuing ‘Design’ phase materializes these ideas into tangible prototypes, with meticulous attention to both technical feasibility and UX considerations. Significantly, the iterative ‘User Testing’ stage engages users in a continuous validation process, allowing iterative improvements based on their feedback, effectively integrating into Scrum's iterative cycles. The iterative nature of UX design operates synchronously with Scrum sprints, exemplifying a perpetual refinement process that adapts to evolving user feedback and project requirements. The combination of these stages within Scrum's iterative framework underscores a harmonious relationship between UX design and development, culminating in a product that impeccably addresses user needs while aligning seamlessly with the principles of agile development.

This project will follow a primary design flow encompassing user research, ideation, wireframing, and design, as well as user testing. In the initial "user research" phase, this thesis project will delve into the historical context of Bennett Place, its present condition, and the

\textsuperscript{7} Scrum is an agile project management framework focused on facilitating collaboration and flexibility in complex projects, commonly used in software development. It involves iterative work cycles called sprints, defined roles like Scrum Master and Product Owner, and regular meetings for planning, review, and adaptation.

preferences of its primary visitors. This research will inform the creation of user persona at Bennett Place, enhancing the understanding of user behavior and their requirements.

Subsequently, this thesis project aims to identify key highlights at Bennett Place that can offer a cohesive narrative experience in our AR application while meeting our target users' needs.

Moving on to the "wireframe and ideation" stage, this thesis project will propose multiple development plans for the AR application, including its wireframe, content structure and AR tracking technology. These plans will be scrutinized for their advantages and limitations, leading to a few prototypes for further testing. In the "design" phase, this thesis project will select one platform to develop the proposed project and build it into executable application that could be installed on mobile devices for user testing. In the last “user testing” phase, this project will recruit few participants to conduct the user testing for further evaluation of AR application with specifically designed criteria, which will provide valuable implications in enhancing the on-site visiting experience at Bennett Place.

### 3.3 How to Evaluate

Evaluating user experience in AR mobile applications presents multifaceted challenges. Robinson et al. highlight the difficulty of establishing consistent evaluation methods across diverse empirical studies. Davidavičienė, Raudeliūnienė, and Viršilaitė undertook a systematic assessment of AR app UX, employing literature reviews, expert evaluations, and user surveys to grasp a comprehensive perspective. They spotlight tools such as the System Usability Scale (SUS), Technology Acceptance Model (TAM), and User Experience Questionnaire (UEQ).

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Additionally, they identify pivotal factors like application purpose, usability, smooth operations, innovative information display, and interactivity.

In 2004, Peter Morville's "UX Honeycomb Method", which delves into seven dimensions that are critical in UX design: “Useful, Usable, Findable, Credible, Desirable, Accessible, and Valuable” (see fig.9). Beginning with the “Useful” dimension, it assesses the applications' ability to effectively solve user problems and cater to their needs. Responses are gathered using a Likert scale, offering insights into users' agreement or disagreement regarding the applications' problem-solving capabilities. Subsequently, the “Usable” dimension examines the ease of navigation and user-friendly interface. Respondents' perceptions of interface navigation and interaction are investigated, shedding light on the seamless nature of user engagement. The “Desirable” dimension explores the visual appeal of the applications. Visual design elements and color choices are scrutinized, capturing the emotional response evoked during usage. The “Findable” dimension probes navigation clarity and feature accessibility. Placement precision and responsiveness are evaluated to enhance user interactions. The “Accessible” dimension evaluates how well the applications accommodate diverse user capabilities. This dimension ensures inclusivity for users with disabilities, making the experience universally accessible. The next is the “Credible” dimension, in which user confidence in the applications' security and accuracy is examined, forming the foundation of trust. Culminating the process is the “Valuable” dimension, weaving together all prior aspects. Users' perceptions of overall worth and impact are gathered, providing a comprehensive understanding of the holistic UX. Through the UX Honeycomb Method, a multi-dimensional perspective is harnessed, integrating functional proficiency with

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emotional resonance in the evaluation process. The confluence of this method synthesizes diverse elements, comprehensively understanding the user experience for the BandoAR and NdoB AR applications. Insights collected through the Likert scale feedback reveal strengths and areas for refinement. This systematic approach, similar to an orchestrated assessment, allows iterative enhancement of the applications' design and functionality. The UX Honeycomb Method proves its usefulness not only by dissecting UX dimensions, but also by providing a valuable guide for navigating refinement of user experience.

3.4 User Testing Methods

User testing, or usability testing, is the process that includes people who are representatives of the target users in the decision-making process to evaluate the degree to which a product meets specific usability criteria. User testing is an indispensable step in UX design. The overall goal of user testing is to enhance design through feedback and insights of target users and reduce user frustration. This project will utilize user testing as a research tool to assess the user experience of the Bennett Place AR application and elevate its usability.

According to Rubin and Chisnell, to start a user testing process, determining the test objective and recruiting participants from the target user group are fundamental. They also emphasize the importance of maintaining a consistent test condition, ensuring that all participants have a nearly identical testing experience. Lastly, a deliberate selection of testing methods is crucial. This directly determines the number of participants required for user testing. In the scope of this project, the primary aim of conducting user testing is to assess the efficacy of this AR

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application in enhancing users’ on-site visiting experience at Bennett Place. To ensure a diverse and representative sample, this project will recruit participants from Durham local community through a multifaceted strategy. Prospective participants will be approached via social media platforms, direct email communications, and in-person invitations. During the user testing, all participants will undergo a rigorously controlled and consistent procedure, ensuring a standardized and uniform experience throughout the testing process.

Several user testing methods are prevalent in the UX design domain, each serving a slightly different purpose. For example, “Formative” tests are conducted during the early stage of project development to evaluate the preliminary design concepts, while “Summative” tests examine how effectively these design concepts are implemented in advanced prototypes. Other testing methods include “Moderated” vs. “Unmoderated” tests that are differentiated by if a moderator will be present during the test. It’s worth noting that the same technique can sometimes be labeled differently, which can lead to confusion. An UX design expert, Jeff Bryant, has proposed a systematic approach to categorize most existing user testing methods. His approach includes two primary categories: “quantitative” vs. “qualitative” tests, referring to the type of data collected, and “attitudinal” vs. “behavioral” tests, indicating the source of information. To be more specific, quantitative tests capture measurable data, whereas qualitative tests involve subjective observations and feelings often articulated in words. In the latter category, attitudinal tests focus on “what people say” and can be conducted without a researcher’s direct involvement. In contrast, behavioral tests center on “what people do” and necessitate at least one researcher to

14 Rubin and Chisnell, Handbook of Usability Testing, 27.
17 These terms are not originated from Bryant.
observe or document the testing, with insights derived directly from them. Thus, by combining
categories, four primary testing methods can be derived: “quantitative attitudinal,” “qualitative
attitudinal,” “quantitative behavioral,” “qualitative behavioral.” Each of these terms, then, fall
into either formative or summative testing, which describe when the user testing is conducted.

Each type of user testing method has its advantages and limitations and requires different
amounts of participants. In this project, only summative testing will be employed to evaluate the
effectiveness of the advanced prototype of the Bennett Place AR application. Within this
framework, both quantitative attitudinal testing and qualitative behavior testing will be employed.
In the qualitative behavioral test, I will enlist two participants and meticulously observe and
document their on-site experience with the Bennett Place AR application. As suggested by
Nielsen and Landauer, observing merely two participants during user testing can effectively
identify a significant portion of usability issues and user frustrations. While the test proceeds,
I’ll remain non-intrusive, keenly noting their spontaneous behaviors. This includes monitoring
facial expressions, tracking time spent at each spot, and mapping their navigational routes. The
whole qualitative behavioral tests will also be recorded. The strength of the qualitative behavioral
test lies in its ability to swiftly highlight major user experience challenges and clearly delineate
effective design elements from problematic ones. Utilizing a small sample size, it allows a deep
understanding of the overall user experience quickly after the prototype is available and provides
insights for the subsequent test before recruiting a large number of participants. However, given
the limited sample size covered by the qualitative behavioral method, the conclusion may be
subject to bias and should not be used as the sole criterion for evaluation. To complement this, a

Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '93, 1993,
https://doi.org/10.1145/169059.169166.
quantitative test is indispensable to provide a more comprehensive and statistically robust understanding of user experience, ensuring a balanced and well-informed assessment.

In the quantitative attitudinal test, considering the limited time frame of this thesis project, 6 participants will be recruited to explore the Bennett Place AR application prototype independently and complete an online survey after their experience. This survey will be structured around the seven “UX Honeycomb” evaluation criteria. By employing this approach, this project aims to engage a sizable test sample efficiently within a limited timeframe. Since a researcher won't oversee the testing phase, participants benefit from flexible testing schedules and can provide feedback at their convenience. Furthermore, the data garnered from quantitative attitudinal tests are straightforward and interpretable. This stems from the structured nature of the survey, which will use standardized questions and fixed response options to gather information. This structure provides a clear and objective numeric or categorical dataset, allowing for straightforward analysis and interpretation. This clarity can streamline decision-making processes and offer a more standardized basis for comparisons and evaluations.

The two testing methods, qualitative behavioral and quantitative attitudinal tests, supplement each other and offer a holistic and robust evaluation of the Bennett Place AR application from a user experience perspective. The qualitative behavioral test can provide a quick understanding of the overall user experience and provide insights that may prevent potential issues of the following quantitative attitudinal test. While the quantitative attitudinal test can provide a structured and clear dataset as a basis for evaluation, questions in the survey sometimes may exhibit bias, potentially influencing participants’ responses. The qualitative

\[19\] Having more participants would enhance the robustness and reliability of the test results, providing a broader perspective and more diverse feedback.
approach bridges this potential disconnect, addressing discrepancies between “what people say” and “what people do.” By integrating both testing methods, this project is positioned to yield more comprehensive and reliable evaluation results.
4. Project Implementation and Process

4.1 Research: Bennett Place

4.1.1 Bennett Place Overview

Bennett Place, also known as Bennett Farm, is a state historic site located in Durham, North Carolina. Bennett Place occupies a unique position in the annals of American Civil War history as the site of the largest surrender of the American Civil War between General Joseph E. Johnston of the Confederacy and General William Tecumseh Sherman of the Union.¹ This farm was established by James and Nancy Bennett in 1840.² Like other typical farming American families at that time, the Bennetts were self-sufficient, but it’s not clear if they owned enslaved workers.³ They not only grew corn, wheat, oats, and potatoes and raised hogs, but also worked as a tailor, a cobbler and sold merchandise, like distilled liquor or tobacco plugs. However, the American Civil War started in 1861 and brought significant tragedy to the Bennett family. Their sons, Lorenzo and Alphonzo, were lost in quick succession during the war. The rest of the Bennett family, James, Nancy and their daughter, Eliza, remained at the farm.⁴

In April 1865, the Civil War was drawing to a close. It was at the Bennett farmhouse that two pivotal figures, General Joseph E. Johnston of the Confederacy and General William Tecumseh Sherman of the Union, convened to negotiate the surrender of Confederate forces spanning North Carolina, South Carolina, Georgia, and Florida. Their negotiations culminated in the largest troop surrender of the Civil War, marking a significant step towards the war's

³ “A Brief History of the Bennett Family,” Bennett Place Historic Site.
⁴ “A Brief History of the Bennett Family,” Bennett Place Historic Site.
conclusion. It's unclear why Bennett Place was chosen for their meeting, but this event underscores the farm's importance, transforming it from a simple agricultural establishment to a site of national significance.

The post-war period brought about changes in the ownership and status of the farm. After the war, James Bennett resorted to a sharecropping system, collaborating with his in-laws. He continued his agricultural endeavors until 1875 and passed away three years later in 1878. The subsequent fate of the farm and its ownership underwent several transitions. While sources offer varying accounts, it is generally accepted that the Bennett family retained possession of the farm into the 1880s. A notable turn of events occurred when Brodie Duke acquired the property in 1890. Duke's ambitious endeavors included an unsuccessful attempt to sell the farmhouse as a historic relic during the 1893 Chicago Exposition. Subsequent ownership shifted to Samuel Morgan, the founder of the Durham Fertilizer Company, who also attempted to elevate the farm's status as a historic site.

After Morgan's death, the original farmhouse suffered neglect and was consumed by fire in 1921, leaving only remnants of its original structure. The 1920s witnessed renewed interest in memorializing the site. Spearheaded by state legislators Reuben O. Everett and Frank Fuller, efforts were made to establish a monument commemorating national unity. The resulting "Unity Monument," erected in 1923, stands as a testament to the reconciliation between the North and South. In the late 1950s, reconstruction of the Bennett house was initiated, funded by a donation

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7 “BENNETT PLACE | Open Durham,” Open Durham.
8 “BENNETT PLACE | Open Durham,” Open Durham.
9 “BENNETT PLACE | Open Durham,” Open Durham.
from Frederick L. Bailey's daughter. By the 1970s, the site had been designated a State Historic Site with a modern visitor center.

Today, Bennett Place is maintained by the North Carolina Division of State Historic Sites and Properties. It functions as both a museum and an educational hub, showcasing reconstructed buildings and exhibits that highlight its pivotal role in American history.

4.1.2 Current Self-Guided Tour and Selected Spots

As a dynamic educational hub for researchers and students, Bennett Place offers a variety of learning opportunities. Visitors can engage in guided tours and specialized programs like "Life of the Civil War Soldier" and "On the Homefront During the Civil War," each offering unique insights into the era. In addition, the visitor center provides a brochure containing information about Bennett Place, including its mission statements, support and contact information, and historical background (see fig. 10 & fig. 11). Notably, the brochure features a self-guided tour, inviting visitors to walk the original Hillsborough Road, retracing the steps of Generals Johnston and Sherman to the Bennett farm. The brochure listed eleven significant spots at Bennett Place, including the Bennett House, Kitchen House, Unity Monument, each spot accompanied by an image and a short description.

Unlike the scheduled guided tours or other educational programs that require prior reservation, this visitor brochure, especially the self-tour guide, provides a flexible and personalized experience to the public by allowing the visitors to explore Bennett Place at their own pace and own route. The tour is designed to be a non-linear, in which visitors decide their own visiting route. They can spend more time at spots that particularly interest them and skip or

10 “Bennett Place State Historic Site,” Bennett Place State Historic Site.
quickly browse through others. This self-guided tour is able to make information about Bennett Place easily accessible to the public. For those who find it challenging to keep up with a group due to language or mobility reasons, they can take breaks as needed during their visit and navigate the site in a way that’s most comfortable for them. For those who are unable to join the guided tour due to schedule conflicts or other reasons, they can plan their visit at their convenience and will not miss out on the highlight spots and their history.

While this self-guided tour offers valuable insights to visitors, the accompanying brochure's design and quality significantly undermine the experience. The brochure, printed in black and white on thin paper, suffers from poor print quality and an outdated design, potentially leading to visitor’s confusion. Each location on the tour is represented by an image in the brochure, intended to help visitors to identify and locate the respective spots. However, the poor print quality, especially given the black and white format, can make image recognition challenging, causing visitors to potentially miss out on key sites. Furthermore, the brochure's overall design lacks structure and visual appeal. Inconsistencies in font size and line spacing, particularly noticeable on the first page, result in a cluttered layout where crucial information fails to stand out. The absence of color and the use of thin paper not only affect the brochure's durability but also its ability to engage and guide visitors effectively.

Given the limited space on the brochure, the descriptions for each location on the tour are very concise and factual, which may lead to potential problems. While they offer an overview of the site's significance, they lack depth, failing to explore the intricate details, historical contexts, or broader implications associated with each location. Visitors are presented with surface-level information that doesn’t weave a cohesive narrative, making it challenging to grasp how each location is embedded in the larger story of Bennett Place, the Civil War, and the era at large. This lack of detailed storytelling can impede visitors' understanding of the site’s significance and their
emotional engagement with it. The narratives are pivotal in bridging the gap between historical facts and human experiences, yet the current descriptions fall short of capturing the struggles, triumphs, and human stories intertwined with each location.

Despite the limitations of this self-tour guide, it can serve as a reference for the Bennett Place AR app proposed in this project, as it has developed a list of spots that are worth noting in Bennett Place. This list can become the framework in developing the Bennett Place AR application for the flexible, accessible, and non-linear nature of the self-guide tour. This project will use the eleven locations listed in the self-guided tour, Hillsborough Road, Morgan Bench, Well with Sweep, Bennett House, Kitchen House, Dairy House, Smoke House, Ash Hopper, Kitchen Garden, Bandstand, Unity Monument, and develop a non-linear AR experience communicating the history of Bennett Place.

4.1.3 Information Collection

A wealth of research, articles, and books have delved into the historical significance of Bennett Place, predominantly focusing on its contribution to the war's interpretation and analysis. However, while the site's Civil War history has been extensively explored, limited studies have ventured into the daily lives, challenges, and contributions of the Bennett family. Due to limited studies about the lived experiences of the Bennett family, this thesis project draws from a number of sources to enrich its digital content.

The book “This Astounding Close: Road to Bennett Place” by Mark L. Bradley provides a detailed account of the site’s Civil War history and valuable historic drawings of the original Bennett Farm. This book is a detailed examination of the final days of the American Civil War,
focusing on the events leading up to the largest surrender at Bennett Place in April 1865. The book delves into the military, political, and social aspects of the war's conclusion. Bradley meticulously chronicles the retreat of General Joseph E. Johnston's Confederate army, the relentless pursuit by Union General William T. Sherman, and the negotiations between these two commanders at Bennett Place. In addition to the historical background of the Civil War, this book includes several drawings of the original Bennett House and the farm, which is included in this thesis project as visual elements. In addition, an article “James Bennitt: Portrait of an Antebellum Yeoman” by Arthur C. Menius III explores the life of James Bennett, examines his personal documents and belongings, and provides insights into James Bennett’s life against the backdrop of socio-economic and cultural landscape of the era. These two sources mentioned above significantly assist the development and refinement of the descriptions of each spot in this thesis project.

Besides relying on primary and secondary academic sources, this project extensively researched online materials concerning the Bennett Family and life in the nineteenth century. To craft the narrative for each location, the thesis drew from several online resources such as the Bennett Place Historic Site, NCPedia, and Open Durham, which offer an overview into the Bennett Family's history and life of the nineteenth century. Additionally, the project consulted

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13 Bennett Place Historic Site is the official website of Bennett Place and is sponsored by the Bennett Place Support Fund. It provides an overview of Bennett Place. NCPedia is an online encyclopedia managed by the North Carolina Government & Heritage Library and contains articles about a broad spectrum of topics and resources of North Carolina’s history, government, and cultural resources. Open Durham is a community-sourced digital archive managed by the local non-profit organization, Preservation Durham, and aims to document the history, people and places of Durham. Open Durham allows individuals to contribute, and, thus, some of its information does not have a clear source and lack of credibility.
open domain digital resources for more detailed information about life in the nineteenth century, encompassing digital exhibits, archives, blog posts, and YouTube videos. By aggregating information from these diverse online sources, the thesis presents a comprehensive narrative detailing the lives of the Bennett Family during the nineteenth century.

The cornerstone of this thesis project is the "North Carolina Lives and Legacies: Bennett Place Project," a comprehensive study conducted in the Information Science + Studies lab (ISS lab) under the guidance of Robert Buerglener during the 2022-2023 academic year. Buerglener, along with a team of Duke University students, embarked on an explorative journey to unveil new interpretative dimensions of Bennett Place through a meticulous examination of existing materials, the integration of newfound historical sources, and the digitization of existing datasets. The team curated an extensive bibliography, offering a rich reservoir of primary research sources about Bennett Place. The digitization of the Bennett Ledger and the visualization of the local US 1850 census data laid the groundwork for a refreshed interpretation of Bennett Place’s role in broader social and economic networks. Furthermore, the team delved into visitor research and conducted a thorough analysis of existing digital platforms associated with Bennett Place. Their rigorous efforts culminated in a substantial compilation of data and sources, establishing a robust foundation for primary research.

In the Summer of 2023, the Bennett Place project, a collaboration sponsored by Duke’s Information Sciences + Studies program, the Duke Library, and the Office of the Vice Provost for Interdisciplinary Studies, initiated a journey of reinterpreting the historical site. Under the

mentorship of Robert Buerglener and Carson Holloway, Duke University students were tasked with generating fresh perspectives on Bennett Place, resulting in the creation of diverse digital projects. These projects explored a range of topics, from Native American trade routes to the North Carolina Railroad. As this project continues to develop, more work will be done in transcribing James Bennett’s account book, digitizing other items from the James Bennett Papers and delving deeper into data from the US Decennial Population Census, the Decennial Agricultural Census, the US Slave Schedules, and other sources. Furthermore, efforts will be intensified to foster relationships with community stakeholders, especially those from previously underrepresented groups like African Americans and Native Americans, aiming to amplify hidden or previously untold narratives.

The "North Carolina Lives and Legacies: Bennett Place Project" is instrumental in shaping this thesis project and offering a wealth of valuable resources. In December 2022, the ISS Lab undertook an exhaustive study of Bennett Place visitors, proposing several visitor categories in order to understand their demographics, visiting goals and area of interests. The insights gleaned from this extensive research equips this thesis project with nuanced understanding of its target audience and facilitates the crafting of detailed user personas in the following section. Moreover, the ISS Lab’s prior investigations into the Bennett Ledger and visualized local US 1850 census data are invaluable. These resources enable the thesis project to weave a compelling narrative for the Bennett Place AR application, spotlighting the Bennett Family’s life and times. As a typical American farming family of the mid-nineteenth century, their story is integral to offering users a comprehensive and immersive historical experience, bridging the past and

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18 This study was based on conversation with Bennett Place staff and was a groundwork for future research with actual visitors.
present and bringing the rich tapestry of Bennett Place to life. Lastly, the digital creations from the 2023 Summer Bennett Place project, including videos, audios, and ArcGIS storymaps, will further augment this thesis project. These multimedia elements will infuse additional layers of depth and engagement, rendering the digital thesis project a rich, multifaceted exploration of Bennett Place’s historical and cultural landscape.

4.1.4 User Persona

A persona is a conceptual model crafted to represent a specific user segment for a product or service. It emphasizes the individual’s goals and interactions, offering insights that are more nuanced than classical user profiles.\(^{19}\) In the case of this thesis project, a user persona describes one of the diverse visitor groups at Bennett Place. Rather than portraying a real or average user, a persona is a fictional yet comprehensive character, constructed from patterns of real or potential users’ behavior, goals, and motives. The made-up personal details enrich the persona, make it more “tangible and alive” for the developer, and foster empathy and a user-centric focus in the design process.\(^{20}\)

As a tool to enhance the understanding of user needs and expectations, the persona ensures that the creation of more user-centric solutions. A persona typically includes the individual’s name, age, occupation, educational background, and other demographic details. It also outlines the individual’s goals, challenges, preferences, and pain points to offer insights into their behavior, needs, and decision-making processes.\(^{21}\) Each persona is tailored for a specific purpose, ensuring that varied user segments and their distinct needs are adequately addressed in


\(^{20}\) Blomkvist, “Persona,” 1.

the design and development phases, leading to more inclusive and effective products and services.

The ISS lab's prior research on Bennett Place visitors reveals a diverse audience, varying in background, age, and visitation purposes. Drawing from this comprehensive study, this thesis project has identified three primary visitor categories: history enthusiasts, family or school field trip attendees, and casual explorers. In this section, the project will describe three distinct user personas, each mirroring the characteristics, objectives, behaviors, and profiles of these visitor categories. These personas will be instrumental in revealing the expectations and pain points of each visitor type during their on-site visiting, thus facilitating design ideations.

History enthusiasts visiting Bennett Place often possess basic knowledge of the American Civil War. They often seek in-depth narratives and history descriptions, especially regarding the significant surrender negotiations between Generals Johnston and Sherman. They also have a keen interest in accessing in-depth and authoritative primary materials, including readings or videos, to enrich their understanding. With this in mind, a user persona for this type of visitors is made:

Persona 1: Alex

Alex is a 45-year-old librarian at Durham County Library. He loves reading and has interests in history, especially about the American Civil War. He enjoys visiting historic sites in the state because he wants to see the place where something significant in history happens and imagine himself taking the journey back to the 1800s. When he visits Bennett Place, he finds that information provided on the self-guided tour is very limited. He expects to obtain knowledge and information from a detailed and precise narrative about the American Civil War and its largest

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surrender at Bennett Place. Access to more authoritative sources, for example, books or videos about Bennett Place would be greatly appreciated by him, so that he could do some reading about Bennett Place in context.

The second visitor type at Bennett Place comprises families and school field trip groups, often with children or students. These visitors are looking for an educational yet engaging experience, with a particular interest in interactive activities. Their preference leans towards concise, easily digestible historical information about the site, including simplified narratives of significant events like the largest surrender of the American Civil War. They value materials that provide a broader historical and cultural context, such as an overview of the war and a timeline, presented in an engaging manner. They are characterized by a desire for a balanced experience that combines educational content with interactive engagement, aiming to make the historical insights accessible and memorable for both young and older visitors alike.

Persona 2: Sarah

Sarah works at a web development company in downtown Durham. She has a daughter, Joanna who is 10 years old at a local elementary school and has very limited background knowledge about American history. Sarah and her husband always bring their daughter to various activities on weekends. When they visit Bennett Place during a family trip, Sarah wants her daughter to have fun while getting some basic idea about Bennett Place and what it’s like to live in the nineteenth century. However, Sarah has no idea about various programs provided at Bennett Place and she finds the self-guided tour is very boring to her daughter.

The third type of visitors at Bennett Place often arrive without a specific goal or deep historical interest. Many are casual visitors, perhaps looking to spend leisure time or those who stumble upon the site and decide to explore. They may have little prior knowledge about the site's historical significance. Their primary interest lies in the natural trails and the serene environment.
of Bennett Place. Information about the outdoor experience, the landscape, and natural trails is more appealing to this group than detailed historical content. They seek a relaxed and enjoyable experience amidst the site’s natural beauty.

**Persona 3: Jessica**

Jessica is 23 years old and works at a local restaurant. She has a dog, so she has to take her dog for a walk every day. She lives around Bennett Place, but she doesn’t know anything about this historic site. She always takes her dog for a walk at Bennett Place, because she likes the natural trail and enjoys the fresh aire. However, her pain point is that she couldn’t find a map at Bennett Place. Sometimes, she wonders to know more about this site, but she doesn’t want to see too much history about this site.

Drawing from the insights gathered from the three distinct user personas, this project has gained a nuanced understanding of its target users, each with unique backgrounds, expectations, and frustrations. These personas, each representing a different visitor type, will inform the design process of the Bennett Place AR application. In the next section, this project will explore several design ideations to meet the specific needs and expectations of each user group. The ideations will address their unique frustrations and aim to enhance their experience by focusing on creating personalized, engaging, and informative interactions at Bennett Place.

**4.2 Ideation: AR Content and AR Tracking Methods**

**4.2.1 Wireframe**

The preceding section outlined three distinct user personas and valuable insights into the diverse backgrounds and varied expectations of Bennett Place visitors. These insights underscore the necessity for a versatile content strategy within this thesis project, ensuring each visitor’s unique needs and interests are addressed.
Recognizing that some visitors may have limited knowledge about Bennett Place or the American Civil War, the project is designed to offer essential background information accessible right from the AR application's welcome page. Users are greeted with four options: “Civil War History,” “About Bennett Family,” “Map View,” and “AR Tour,” each leading to content curated to enhance their specific experience (see fig. 12). The “Civil War History” and “About Bennett Family” sections offer textual and visual overviews, ensuring all users begin their AR tour with a foundational understanding. A digital map caters to those keen on exploring the natural trails of Bennett Place. On the "AR Tour" page, visitors can explore Bennett Place with a detailed audio guide and view digital elements overlayed on their surrounding environment through their mobile device screens.

The diversity in visitor profiles necessitates a flexible content approach. History enthusiasts seek detailed descriptions and primary historical materials, while families and school groups favor concise, engaging narratives. The latter group, especially, values interactivity to enhance the learning experience for children. Casual visitors, on the other hand, are more inclined towards the natural aspects of the site, with less emphasis on historical content. Considering these varied preferences, this thesis project proposes a 3-level information structure for the AR tour. The first level offers brief, factual information of each spot, designed for a quick read under 30 seconds. Historic images, drawings and sketches are also presented in the first level, in order to provide a quick overview of the original look of the spot. The second level includes engaging narratives about the Bennett Family and the broader cultural and social contexts of the nineteenth century. Digital content, including 3D models, gifs and images, about life in the nineteenth century is shown in the second level. This section of information is designed to be finished in about 1 minute. The third level provides links to external websites for in-depth historic information and more primary historical sources and may take more than 5 minutes to finish.
As visitors begin on the AR tour and reach designated locations, only the first level of content will be presented. Users have the option to delve deeper into the second and third levels by clicking the “More Information” button, or proceed to the next spot, allowing for a customized experience based on individual interests and time constraints. This adaptive content structure ensures a personalized, enriching experience for every visitor, regardless of their background or purpose of visit.

4.2.2 Digital Content

Aiming to provide visitors at Bennett Place an enriching and immersive experience, this thesis project employs a diverse array of digital content. In the AR tour, information of each spot, including the first-level factual description and the second-level narrative, is available in both audio and text format. As the user approaches a designated location, an audio indicator will first be activated, followed by an auditory description of the spot. For accessibility purposes, the same information is also available in text format via a “Text Description” button at the upper right corner of the screen. The combination of both audio and text format description ensures that the experience is both engaging and accessible to all visitors.

To further enrich the AR experience and assist the comprehension of historic information and narratives, this thesis project also includes historic drawings and diagrams, pictures, gifs and

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23 Figma is a web-based prototyping and design tool. It offers functions to create interactive prototypes and design specifications.

24 The auditory descriptions used in this thesis project are AI-generated from NaturalReader and can be downloaded for personal use. Audio indicator used in this project is available on the FreeSound website and can be downloaded for personal use.
3D models. These digital materials can juxtapose the past with surrounding environments, assist information comprehension and boost interactivity, leading to an immersive, engaging and informative AR experience. For instance, the spot “Hillsborough Road” marks the meeting point of the two generals. An historic drawing from Harper’s Weekly (see fig. 14) is used to depict the scene at Hillsborough Road, projecting the famous scene to present realities. The spot “Ash Hopper” is another example. While the original object no longer exists, the picture of an ash hopper that once existed at Bennett Place (see fig. 15) stands in its place, providing the user a clear visual representation. 3D models are also applied in the AR tour, bringing the 19th century environment to life. At the spot “Kitchen Garden,” as the narrative introduces the variety of plants that once grew in the Bennett Farm’s Garden, 3D models of plants, vegetables and apple trees recreate the garden’s original look (see fig. 16), leading to a vivid and engaging experience. A comprehensive plan of the descriptions and digital media used for all 11 selected spots can be found in Appendix B.

4.2.3 AR Tracking Method Ideations

Augmented Reality (AR) tracking is a pivotal component of AR technology that involves the real-time localization and orientation of objects within the user's environment. It enables the seamless integration of virtual elements with the real world, enhancing the user's perception and interaction with their surroundings. AR tracking methods can be broadly classified into marker-based and marker-less tracking. Marker-based tracking uses physical markers, such as images or

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25 All images used in this thesis project are public online and can be downloaded for personal use. 3D models used in this project are from Sketchfab and can be purchased and downloaded for personal use. 26 Toqeer Ali Syed et al., “In-Depth Review of Augmented Reality: Tracking Technologies, Development Tools, AR Displays, Collaborative AR, and Security Concerns,” Sensors 23, no. 1 (January 1, 2023): 7, https://doi.org/10.3390/s23010146.
QR codes, placed in the environment to trigger virtual objects. The AR system identifies these markers to determine the position and orientation of virtual objects. For example, in retail, a QR code on a product package can be scanned using an AR application to display virtual information or features of the product in 3D. On the other hand, marker-less tracking doesn't rely on predefined markers. It leverages advanced localization technologies like Global Positioning System (GPS), Radio Frequency Identification (RFID), and sensor technology to establish the relative positioning between virtual objects and the real world. They can be generalized into two categories: sensor-based tracking, where accelerometers and gyroscopes in devices track user motion, and vision-based tracking, employing cameras and algorithms to identify environmental features (see fig. 17). Previous studies have been done in summarizing each type of AR tracking techniques and analyzing its advantages, challenges, and example application areas. These studies offer a roadmap for understanding their intricate functionalities and potential applications in diverse fields.

Marker-based tracking, particularly through scanning QR codes, is a prevalent, accurate, and stable AR technology that is also cost-effective. It has found applications in diverse fields and has become a ubiquitous element of our daily lives. However, the integration of AR markers, especially QR codes, at historical sites sometimes may be intrusive and disrupt the aesthetic and cultural integrity of these locations. Therefore, it is also worthwhile to explore marker-less tracking techniques and remove the AR markers from historic sites. In the context of this thesis, which is centered around an outdoor guide tour at Bennett Place, the focus has the potential to

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shift to a marker-less approach utilizing GPS for location tracking. GPS technology facilitates outdoor tracking by referencing the Earth’s coordinates, offering a viable alternative to marker-based methods. The inception of GPS in AR can be traced back to 1997 when Feiner et al. introduced "A Touring Machine," a pioneering application that showcased the potential of overlaying additional information onto the real world using GPS. The prevalence of GPS-enabled mobile devices today has broadened access to this tracking method to the public. However, it has to be noted that, since the present accuracy of the GPS system is up to 3 meters, the GPS tracking is optimally employed in scenarios where precise pose registration is not a critical factor.

Both marker-based and marker-less tracking technologies offer distinct advantages and disadvantages. In understanding the application of AR on visiting experience at Bennett Place, it’s worthwhile to examine these two tracking methods at the same time, by conducting a comparative study in the user testing process discussed in the previous chapter. Specifically, the AR application will be developed in two versions (GPS and QR code version), with identical in content and structure but different tracking methods applied. One version will use QR-code as its core tracking method, while the other will use GPS tracking. For the user testing phase, participants will be assigned into two groups. One group will engage with the QR code version application, and the other will explore the GPS version. Through the behavioral qualitative testing and attitudinal quantitative testing procedures described in the previous chapter, the result from

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this comparative study will be instrumental in discerning the effectiveness of these two AR tracking methods for enhancing visitor engagement and experience at a historic site.

4.3 Design: AR Implementation Process

4.3.1 Digital Tools: Unity and Vuforia

A variety of Augmented Reality (AR) development and authoring tools are available today, including low-level software libraries, game engine plug-ins, platforms, and standalone applications. The selection of a particular tool is contingent upon several factors, including the intended platform (web or mobile), the tracking technology employed, and the developer's programming expertise. Low-level software libraries, like ARToolKit, Goblin XNA, and BazAR, offer flexibility in support of tracking technologies and platforms, but they demand a high level of technological and programming skills of the developer. In contrast, standalone AR tools, like Wikitude Studio and BuildAR, are designed for developers with limited programming knowledge. They offer intuitive graphic user interfaces that facilitate the creation of AR experiences and support a variety of media including images, videos, text, sounds, animations, and 3D models. However, a significant limitation of these tools is that they primarily only support marker-based and computer vision-based tracking. Plug-ins, such as Vuforia, ARCore and ARKit, can be an alternative by adding AR functionality as software packages to existing authoring tools and game engines. These are particularly beneficial for developers who have previous experience and skills with specific engines or tools, enabling the integration of AR features with relative ease and efficiency.

Considering the design objective of this thesis project, this project specifically choose Vuforia as the primary development tool for the following reasons: 1) Vuforia supports multiple tracking technologies, like marker-based tracking, model-based tracking and GPS tracking, which aligns with the project’s aim to evaluate multiple tracking methods; 2) it can be used as a plug-in to Unity, a cross-platform game engine with which I have previous experience, facilitating a streamlined development process; 3) it’s an active AR development tool and has free version available. By employing Vuforia and Unity as the primary AR development tools, this project will be able to explore the proposed comparative analysis of marker-based and GPS tracking technologies in the context of a historical site. Moreover, the synergy between Vuforia and Unity allows for the creation of AR application compatible with both Android and iOS platforms, ensuring that the Bennett Place AR application, as a mobile application, is accessible to most users.

4.3.2 Vuforia License and Target Database

Starting a new project in Unity involves preparatory steps in Vuforia. The first step is obtaining a Vuforia license to enable AR functionality in Unity. Vuforia offers a basic license, which is free and intended for development and testing but includes a watermark on some advanced features, and a premium license, which incurs a fee and is meant for commercial use. Due to the scope of this project, this thesis project applies for a basic license. This license is obtained from the Vuforia Developer Portal, and a key is provided, which will be added in the Unity project (see fig.18).

The next step is to create a target database that identifies targets for the proposed tracking functions. This thesis project uses the Vuforia Target Manager, a web-based tool for developers to create and manage target databases. Developers can upload their proposed targets to Vuforia Target Manager for visual evaluation and processing. In the context of this project, since GPS
tracking utilizes universal GPS coordinates as its targets, the pre-processing of the target database can be skipped. The “Unity AR + GPS Location” package will be imported into the Unity project to facilitate this process. For marker-based tracking, QR codes associated with each spot are used as primary targets. These QR codes are uploaded to the Vuforia Target Manager. After processing, a target database is created and exported as a “.unitypackage” file that later can be easily imported into the Unity project folder (see fig. 19).

4.3.3 Unity Implementations

In this thesis, two separate Unity project files are developed, one using marker-based tracking and the other using GPS tracking, because these two tracking methods require different setups in Unity. However, both projects share the same wireframe and user interface. The initial phase of development is identical for both, including the creation of the application's user interface and structure within Unity. This is achieved through C# scripts and Unity's UI functions, ensuring consistency in user experience while accommodating the distinct tracking methods (see fig. 20 & fig. 21).

In the marker-based tracking project, integration of the Vuforia Engine is the subsequent step. This software development kit (SDK), downloadable as a “.unitypackage” file from the Vuforia website, equips the Unity project with the capability to recognize and interact with images, objects, and spaces in the real world. After importing the SDK, the Vuforia Engine option becomes accessible in the GameObject Menu. An ARCamera GameObject (AR Camera), a crucial component for any scene that tracks and renders augmented content, since ARCamera

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34 The QR codes used in this project were generated from an online QR code generator “草料二维码生成器,” https://cli.im.
allows the streaming of a live camera view within the application. With the ARCamera in place, the Vuforia developer license key, obtained earlier, is entered into the Vuforia Configuration in the Unity inspector (see fig.22). Eleven Image Target GameObjects (Image Targets) are then added into the scene. Each Image Target is configured to “from database” type and assigned a specific QR code from the database. This setup enables the QR codes to function as markers for AR tracking and activate the augmented digital content. The digital content, made as “prefabs” in the project, is added as “children” of each respective Image Target (see fig. 23). This arrangement ensures that scanning a particular QR code triggers the corresponding digital augmented content in this project.

For the GPS tracking project, the setup is different. Instead of incorporating the Vuforia SDK, AR Foundation is installed from the Package Manager in Unity at the first step. Although AR Foundation isn’t directly utilized, it can avoid potential scripting errors in the following project development. Then, the “Unity AR + GPS Location" package, available in the Unity asset store, is imported to the Unity project. This package sets up the project ready for adding GameObjects from Vuforia Engine, including AR Camera, Plane Finder and ARLocationRoot. Subsequently, eleven GPS Stage Objects are added, each configured with specific GPS coordinates of Bennett Place via the PlaceAtLocation inspector (see fig. 24). Digital content is also made as “prefabs” in this project and added as “children” of each GPS Stage Object (see fig.25). This thesis project specifically employs the Hotspot function of the GPS Stage Objects, enabling the digital content prefabs to be activated when the user enters the preset Activation Radius of the designated GPS locations. The Activation Radius is set to 5 in this project, which

means when the user is within 5 meters to the designated GPS location, digital content prefab will be triggered on the screen. At the same time, the Deactive On Leave function is set to be true, and the Deactivation Radius is set to be 10 in this project, meaning that the digital content prefabs on screen will be deactivated when the user moves more than 10 meters away from the designated GPS locations (see fig. 26).

Additionally, during the prototyping process, it’s found that users are likely to miss some locations without any guidance for both ideations. Even though this thesis project doesn’t aim to guide the user to visit Bennett Place in a specific order, an additional map, accessible from the button “map” at the upper right corner of the screen, is added into the AR experience to provide an overview of selected spots for the user. Upon completion of these steps, both Unity projects, each utilizing a distinct tracking method, are ready to be built as a mobile AR application.

4.3.4 Executable Mobile Applications

To facilitate the user testing phase, this thesis project needs to be converted into a downloadable mobile application, enabling participants to easily install it on their personal devices. While both Unity and Vuforia are compatible with iOS and Android, both versions of the AR app - one utilizing marker-based tracking and the other GPS tracking - will be exclusively developed for iOS for testing purposes.

When the application is completed in Unity, the next step is to set the build platform to iOS in “Building Setting” and adjust the player settings. Given that the AR application will require access to users’ personal information, like location and camera, it is imperative to fill camera and location usage descriptions in the player setting. This clarifies the necessity of permissions to the users, protecting user’s private information and ensuring transparency of this project (see fig. 27). Upon selecting the “Build” button, all assets and scripts within the Unity project are packed into a local folder on my laptop. The subsequent step uses Xcode to convert
this folder into an executable app on iOS mobile devices. Xcode, available on the App Store, is a comprehensive development environment equipped with a range of tools specifically designed for creating software within Apple’s ecosystem, including iOS. The final steps include setting up signing with the Apple developer account in Xcode and installing the mobile AR application on iOS devices that are connected to my laptop through Xcode. This process ensures that the application is readily accessible for user testing.

The iOS application created for this project can be published on the App Store, accessible to anyone with an Apple account. However, this requires enrollment in the Apple Developer program and a subscription fee. Given the constraints of this thesis project, the decision has been made to forgo immediate publication of the Bennett Place AR applications on the App Store. Future plans to extend the project may include publishing the applications to broaden accessibility and engagement, enhancing the project’s reach and impact.

4.3.6 Project Demonstration

The final delivery of this thesis project is an iOS application with two versions, differentiated by its AR tracking method used: QR code or GPS. The user will start with the same welcome page that includes four menu buttons, “About Civil War History,” “About the Bennett Family,” “AR Tour,” and “Map,” that lead the user to four new pages (see fig. 28). The pages for “About Civil War History,” “About the Bennett Family,” and “Map” offer contextual background about Bennett Place and are identical in both app versions (see fig. 29 - 31). In the “AR tour” page, users can see a live view of their surroundings through their device's camera with a banner prompting them to enable sound and a button linking to the map of Bennett Place (see fig. 32). Throughout the AR experience, a return button is always available in the upper left corner of the screen, allowing users to navigate back to the welcome page at any time.
In the AR tour page of the GPS version app, users are able to hear an audio indicator when they reach the active area of each location at Bennett Place, followed by a short audio clip of factual historical accounts of the location. From the screen of their mobile devices, they could also see an historic image overlaid to the real environment. Two more buttons, “More Information” and “Text Description,” are also added to the page at the same time (see fig. 33). This marks the successful access to the first level of content at each location. Users can click “Text Description” to see a text version of the audio clip (see fig. 34). They have the option to proceed to the second level of information by clicking the “More Information” button or move to the next location. Selecting the “More Information” button triggers the second audio clip with humanistic narratives and replaces the initial image with a new one or a digital model, signifying the second level of content (see fig. 35). Similarly, they can continue to explore more additional historical materials by clicking “More Information” again, which leads them to the third level of content, or leave this location directly. The third audio guides users to open the “Text Description” page and explore links to external websites of related topics (see fig. 36). The QR code version of the app shares the initial interface with the GPS version. However, it requires an additional step: users must manually scan a QR code at each location to access the digital content (see fig. 37). Once the QR code is scanned successfully, the same design of audio indicators, descriptions, and images as in the GPS version is triggered. The subsequent experience, including the options to access more information or proceed to the next location, mirrors that of the GPS version.
4.4 User Testing

4.4.1 Measurements and Survey Questions

In the previous chapter, the "UX Honeycomb Method" is identified as the principal evaluation tool for this thesis project, including seven dimensions: usefulness, usability, findability, credibility, accessibility, desirability, and value. In the context of this thesis project, “usefulness” assesses the AR application's ability to provide information that matches visitors' goals at Bennett Place. “Usability” refers to the ease with which users can trigger digital content and description at designated spots, effectively reaching the desired information, while "findability" evaluates the efficiency of locating these spots. "Credibility" examines users' trust in the application's information. "Accessibility" determines how easily users can interact with the digital elements at each spot. "Desirability" quantifies the users’ motivation to explore all eleven spots, and "value" compares the app experience to traditional guided tours. Based on these elements, this thesis project develops specific measures for the qualitative behavioral testing and survey questions for the quantitative attitudinal testing.

In the qualitative behavioral testing phase, this thesis project aims to meticulously evaluate participants' user experience. Key metrics include the amount of digital content consumed, time spent engaging with each content segment, and the success rate of triggering digital content at designated spots. The efficiency of users in locating these spots and their chosen routes is also analyzed. Attention is also given to participants’ awareness of information sources and any challenges faced in accessing highlighted spots or digital content. The total number of spots reached, and digital content triggered, as well as any missed spots, is recorded. Each participant’s entire experience is documented in Appendix C, with detailed notes on these metrics taken for further analysis.
In the quantitative attitudinal testing, participants receive an online survey after testing, as outlined in the previous chapter. The survey is designed to include four sections and has two versions, which are QR Code version and GPS version, differentiating by the applied tracking method. The first three sections are identical in both versions, with only the last section being different. It has been declared at the beginning of the survey that information collected in this survey is used for the purpose of this thesis project only. The first section collects biographical information, like name, email, previous experience of using AR, and their relation to Duke University. The second section consists of multiple-choice questions that focus on factual details of their experience, such as the locations participants visited, their estimated time of the experience, the segments of information they accessed, and their interactions with the app. Some questions are accompanied with example images for clarification. The third section focuses on participants’ attitudes and feelings. Some questions are followed by short-answer queries, allowing participants to provide context or elaborate on their experiences. These attitudinal questions are derived from the seven evaluation dimensions previously discussed. The fourth section is dedicated to assessing the two tracking functions: QR codes and GPS. Participants are given a version of the survey that matches the tracking function they experienced—those who used the GPS tracking function receive the GPS-version survey, and those who used the QR codes tracking function receive the QR code-version survey. This section includes questions about their prior experience with the tracking method, its impact on their experience, any challenges encountered while using the tracking functions, and their openness to using a similar

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The survey was designed and distributed through Google Forms, a free online tool provided by Google for creating surveys and quizzes. It provides a variety of question types, such as text, multiple choice, checkboxes, and more. Responses to the forms are automatically collected in Google Sheets and can be viewed in real time. This tool offers an easy method to distribute the survey and collect responses.
app at other historic sites. At the end of this section, participants are presented with a short answer question, inviting them to provide any additional comments or feedback. Appendix D shows a comprehensive list of the survey questions for both versions.

4.4.2 User Testing Process and Documentation

In qualitative behavioral testing, two participants were recruited. They were both master students at Duke University and didn’t have previous knowledge about Bennett Place. The tests were conducted on Saturday, November 4th, 2023. Prior assistance of installing the mobile app on their personal mobile devices was provided. One of them installed the GPS version (a.k.a. GPS user), and the other installed the QR code version (a.k.a. QR code user). A detailed documentation of qualitative behavioral testing is shown in Appendix C.

The GPS version test started at 3 PM and lasted approximately 14 minutes. The GPS user was informed about the AR application's reliance on GPS to activate digital information. She visited 9 of the 11 spots, missing 2 during her tour. Although she could activate the digital content, she needed to physically move around to find digital items like images and took some time to familiarize herself with the app's wireframe and functionality (see fig. 38). Notably, she did not consult the map or external links provided in part 3 in the app. Despite this, she efficiently located most spots, which were clearly marked on-site, but missed two spots. Notably, she took a picture of the Unity Monument using another mobile phone. (see fig. 39) Table 1 provides a comprehensive review of this test on GPS version and corresponds to the metrics outlined in the previous subsection. This table systematically captures the performance and experiences of the participant.
Table 1: Documentation of qualitative behavioral user test (GPS version).

<table>
<thead>
<tr>
<th>Qualitative Behavioral Test 1</th>
<th></th>
</tr>
</thead>
</table>
| **Amount of digital content accessed** | Audios: 9/11  
Visals: 8/11  
Texts: 2/11  
External links: 1/11 |
| **Time spent at each spot** | Hillsborough Road: 2 mins  
Unity Monument: 1 min  
Bennett House: 1 min  
Kitchen House: 1 min  
Smoke House: 1 min  
Dairy House: 30s  
Well with Sweep: 30 s  
Bandstand: 1 min  
Morgan Bench: 30 s |
| **Success rate of triggering digital content** | 9/9 |
| **Efficiency of locating spots** | Overall, she could locate most spots easily. She was a little bit confused after “Dairy House.” |
| **Awareness of information source** | 0/11 |
| **Number of spots reached** | 9/11 |

The QR code version test began at 3:30 PM and took about 21 minutes. The QR code user was also informed that this AR experience's mechanism was QR code activation. Due to the necessity of Bennett Place management's permission for on-site QR code placement, a special brochure with a map and QR codes was created to facilitate the test (see fig. 40). He successfully visited all 11 spots and quickly grasped the app's wireframe and functionality (see fig. 41). He engaged with both part 1 and part 2 information at most spots, choosing to skip the part 2 content only at the Ash Hopper. This participant also spent additional time at locations with more interactive digital content, such as 3D models. In table 2, a comprehensive review of the second test is shown.
Table 2: Documentation of qualitative behavioral test (QR code version).

<table>
<thead>
<tr>
<th>Qualitative Behavioral Test 2</th>
<th></th>
</tr>
</thead>
</table>
| Amount of digital content accessed            | Audios: 11/11  
|                                                | Visuals: 11/11  
|                                                | Texts: 2/11  
|                                                | External links: 2/11 |
| Time spent at each spot                       | Hillsborough Road: 2 mins  
|                                                | Unity Monument: 45 s  
|                                                | Bennett House: 1.5 min  
|                                                | Kitchen House: 1.5 min  
|                                                | Kitchen Garden: 2.5 mins  
|                                                | Ash Hopper: 30 s  
|                                                | Smoke House: 1.5 min  
|                                                | Dairy House: 2.5 min  
|                                                | Bandstand: 1.5 min  
|                                                | Well with Sweep: 30 s  
|                                                | Morgan Bench: 30 s |
| Success rate of triggering digital content    | 11/11    |
| Efficiency of locating spots                  | The map on brochure was very helpful in locating spots. |
| Awareness of information source               | 2/11     |
| Number of spots reached                       | 11/11    |

The quantitative attitudinal test was conducted on the same day, including 6 participants. Three of them used the Bennett Place AR app with GPS tracking function (a.k.a. GPS group). After their experience they were assigned an online survey in the GPS version. Similarly, the other three participants used the app with QR codes tracking function (a.k.a. QR code group). The same brochure with a map and QR codes were given to each participant. After their experience, they received the QR code version survey. All the six participants responded to their survey. Their responses were collected by Google Forms.
4.4.3 Results and Findings

Given the small sample size of the user testing process in this thesis project, it's important to acknowledge that the results may be biased and should not be viewed as conclusive. In the qualitative behavioral test, even though both participants followed a similar route and the average time they spent per location was remarkably close, some differences can be noticed from the detailed observation and documentation on their behavior.\(^3\) First, the QR Code user was able to quickly comprehend the mechanism and structure of the app, while the GPS Participant required about 3 - 4 minutes to grasp the mechanism and interface. In addition, the GPS user only noticed prominent locations. The GPS user missed spots like Kitchen Garden and Ash Hopper that were either small or had been removed from the site. The GPS user didn’t Well with Sweep by herself, but accidentally reached its active area and found this spot at surprise. Conversely, the QR code user was able to identify all spots. Lastly, the GPS user occasionally felt unsure about navigation and the next location. When she walked around the houses, she was uncertain if she should go to the bandstand or chairs nearby. In contrast, the QR code user had a clear sense of direction and exhibited greater confidence.

In the quantitative attitudinal test, some consistent patterns were observed across both versions of the survey. The majority of participants completed their tour within 5 to 15 minutes. All six participants were able to engage with the "More Information" feature, which provided additional narratives and visual elements. They were all able to effectively interact with the audio descriptions and visual elements at each location they visited. Text descriptions and external website links were utilized by participants in both groups at a few locations, like Hillsborough.

\(^3\) Participants using GPS visited 9 locations in 14 minutes and the average time for her on each location is 1.6 minutes. Participants using QR codes visited 11 locations in 21 minutes and the average time for him on each location is 1.9 minutes.
Road, Bennett House, and Kitchen Garden. However, one participant especially pointed out the usefulness of this feature to non-native speakers. Participants found the audio descriptions and visual elements to be the most engaging aspects of the AR tour. They could readily locate desired information, such as historical narratives and interactive features. The majority did not pay attention to the sources of information, nor did they consider them significant. Most preferred the app experience to a traditional guided tour.

Some patterns emerged related to the tracking methods used. Out of six participants, four managed to visit all 11 locations. However, two individuals in the GPS group missed several spots. Moreover, two of the three participants in the GPS group reported feeling lost or uncertain about the location of the next spot, unlike the QR code group, where all participants felt confident about where to go next. Furthermore, all participants in the QR code group were accustomed to the QR code tracking method, whereas for most in the GPS group, the GPS tracking function was a novel experience. A greater number of users in the QR code group felt that the tracking method altered their intended route and found it somewhat intrusive. Conversely, the majority of users in the GPS group felt that the tracking did not interfere with their choices of route and was non-intrusive to their visit.

In general, the Bennett Place AR app offers an engaging and informative experience. Most users can complete the AR tour within a reasonable timeframe, suggesting a well-balanced amount of information and content. At the same time, users can easily navigate in the app and engage with digital content, like auditory and visual elements. The inclusion of text descriptions is also critical for accessibility purposes. The AR experience is generally preferred over

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30 The brochure with map and QR codes for the QR code test may have influenced the participants' experiences. If future user tests allow for QR codes to be placed directly on-site, these results are subject to change.

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traditional guided tours, highlighting its potential for broader application at other historic sites. Also, different tracking methods used in the AR app may lead to distinctive experiences. The use of QR code tracking, familiar to most users, minimized the learning curve and allowed for focused content engagement, though it somewhat restricted free exploration and could intrude on the natural visiting experience. In contrast, GPS tracking offered a freer exploration experience, potentially leading to serendipitous discoveries, despite some users feeling uncertain about navigation.

4.5 More Iterations and Experts Feedback

4.5.1 The Second Iteration and Experts Feedback

The iterative nature of the UX design flow used in this project dictates that it should continuously refine, advance, and evolve based on observations and feedback from user testing. This leads to subsequent iterations of the project. Each new iteration should also undergo rigorous testing and analysis for further improvements and refinement. A timeline of each iteration and the corresponding user testing phases is shown in fig. 42.

Although the initial user testing's limited sample size did not provide a comprehensive overview for evaluating the application, it did reveal some critical issues. These findings led to further refinement and the creation of a second iteration. This iteration enhances the User Interface design by adjusting font sizes, margins, color choices, and button labels. It also introduces two new functions: the ability to pause audio descriptions and return to the previous audio clip. Additionally, the name of each location is now displayed at the bottom of the screen (see fig. 43). For the GPS version of the second iteration, activation areas are meticulously chosen and placed to prevent overlapping. In the QR code version, the project shifts from setting prefabs as “children” of each Image Target in Unity to using C# codes for controlling the placement of
visual elements (see fig. 44). This approach ensures that the visual elements remain stable in the camera view when the QR code is removed.

Three experts from the committee were invited to test both versions of the second iteration at Bennett Place, offering invaluable insights and identifying critical issues to enhance the app's user experience. They pinpointed problems such as image ratio distortion, the height of visual elements, and map orientation. Additionally, they recommended the creation of a project website for documentation and remote access. A key suggestion was to embed an interactive map in the website, providing a clear indication of the activation areas for the GPS version. Notably, during the testing of the QR Code version, a new issue emerged related to the registration of visual elements with QR codes. This issue was thought to be associated with the use of different devices.

4.5.2 The Third Iteration

The third iteration incorporates several modifications based on the feedback received during the expert review session. Firstly, the welcome page's original map is replaced with one that features eleven clickable pictures of all spots, providing a more interactive experience. This new map is also oriented to match the visitor's initial position and includes detailed map legends (see fig. 45 & 46), allowing users to easily identify each location and orient themselves at Bennett Place. Additionally, an ArcGIS StoryMap with an interactive map tour has been created and linked to a newly added “Project Website” button on the welcome page. This enables users to access historical information remotely (see fig. 47). The ArcGIS StoryMap serves not only as documentation for the project but also broadens its public accessibility, catering to those who cannot physically visit Bennett Place. In response to the image ratio distortion issue, the project resets the size of all images using C# code, ensuring they maintain their original ratios (see fig. 48). This provides a universal and convenient solution for preserving image ratio in the
application. Furthermore, coding efforts have been made to prevent repeated activation, although further on-site testing is required to confirm its functionality.

In the third iteration of the AR tour for the GPS version, a new feature called "My Map" has been added (see fig. 49). This map marks all eleven selected spots at Bennett Place, each with a colored circle indicating the activation area and a gray circle representing the deactivation area. These spots and circles are accurately placed using the same GPS coordinates and activation/deactivation radius values as defined in Unity. This interactive map is designed to show users their real-time location in relation to the eleven marked spots, aiding in navigation and reducing confusion during their experience. Additionally, the height of the visual elements has been adjusted to be relative to the camera. This adjustment ensures that the visual elements maintain a consistent and reasonable height for all users.
5. Implications, Values, Limitations and Future Directions

5.1 Implications

This thesis project stands as an illustrative example of how Public Digital Humanities can be enhanced through User Experience (UX) design. It investigates established UX design processes, applying them to the digital humanities to streamline complex development tasks. The project follows a four-step UX design flow— research, wireframing and ideations, design, and user testing. By integrating a UX design flow with a public digital humanities project, this thesis project ensures the presence of “the user” throughout its development process. In creating the descriptive content and considering information structure, the use of user personas allows this thesis project to obtain a deep understanding of user’s needs and behavior, ensuring digital content fits the expectation of the majority and is placed in an effective order. To be more specific, according to the three distinctive user personas, this thesis project decides to employ a three-level information structure, with each level presenting different amount of information, including brief historical accounts, humanistic narratives about the Bennett Family and lifestyle in the 19th century, and primary and secondary historical materials and reading. By marrying UX design with digital humanities, the project not only simplifies the development process but also places the user's needs and experiences at the forefront. This user-centric approach is crucial for creating digital humanities projects that are not only informative but also engaging and accessible to the public.

While the user testing for the Bennett Place AR app doesn't offer conclusive results about its effectiveness, it has been crucial in shedding light on potential approaches for crafting user tests in public digital humanities initiatives. The meticulous organization of user tests, the creation of clear evaluation criteria, the development of precise metrics and survey questions, and
the thorough documentation of the entire testing process have all contributed to a deeper understanding of user interactions and reactions to the AR experience. This structured and reflective method of user testing extends beyond the scope of this project, indicating that it could be feasibly applied to other public digital humanities projects to evaluate their effectiveness and success.

Additionally, the patterns and insights from user testing offer reflections on the seven evaluation criteria of the UX Honeycomb method. In general, the Bennett Place AR in both versions can be considered "Valuable" due to its potential applicability to other historic sites and its effectiveness as a supplement to existing guided tours. Its "Useful" dimension is demonstrated by its capability to provide information that meets the expectations of most users. The aspect of "Credibility," however, requires more in-depth discussion. While most users were able to identify the sources of information during their experience, there was a tendency to underemphasize the importance of these sources. This indicates that users might inherently trust the information presented in the app, influenced perhaps by Bennett Place’s status as a state historic site and educational center, which naturally carries public credibility. Yet, it is crucial to consider who controls the interpretation of such a historic site. For instance, the narratives in this thesis project, influenced by my personal perspective, might inadvertently focus more on topics like the role of women in the Bennett Family, potentially leading to a neglected consideration of other historical viewpoints. This could result in a biased understanding and interpretation of Bennett Place and its era. Therefore, digital projects with an educational aim need more thorough attention and discussion to ensure that users recognize the multi-faceted nature of history.

When evaluating the GPS and QR Code versions of the app using other dimensions of the UX Honeycomb method, distinct performances are observed. The "Usable" dimension reveals more challenges in the GPS version, mainly due to the constantly updating GPS coordinates on
users' mobile devices and the limitations in the precision of current GPS technology. In contrast, the QR Code version could be deemed more "Usable," offering a stable and straightforward experience for all users. In the "Findable" aspect, the QR Code version appears more efficient. The on-site markers (QR codes) provide visual guidance in locating the eleven selected spots. However, these markers can interfere with the user experience by causing users to focus more on finding the next marker than enjoying the historic site and can potentially disrupt the site's overall aesthetic of the historic site. The "Desirable" dimension is greatly influenced by users' familiarity with the tracking methods used. The GPS version introduces a novel tracking approach unfamiliar to most users, resulting in a steeper learning curve. This unfamiliarity and the extended learning process may reduce users' confidence in using the app, making the GPS version less "Desirable."

Conversely, QR code tracking is a common feature in everyday life, and most users have previous experience interacting with QR codes. This familiarity likely increases users' confidence in using the app and their willingness to explore the site with it.

Addressing the "Accessible" dimension, both versions of the app face potential accessibility challenges. The project strives to offer an inclusive experience, providing both auditory and text descriptions, but the AR tracking techniques employed may pose access barriers. The use of either app version requires a smart mobile device with a camera and internet connection. This prerequisite could be problematic for individuals who do not have access to such technology. For the GPS version, accessibility issues may arise for users with mobility impairments. These individuals might find it challenging to physically reach the designated activation areas, thus limiting their access to information at certain locations. In the case of the QR Code version, users with visual impairments may face difficulties in identifying or scanning the QR codes, potentially excluding them from the AR experience. These accessibility concerns highlight the need for additional considerations and possibly alternative solutions to ensure that
the app is truly accessible to a broader spectrum of users, regardless of their physical abilities or technological access.

5.2 Values

Reflecting on the UX Honeycomb method's seven dimensions, both the GPS and QR Code versions of this AR project exhibit distinct values and limitations. This analysis provides insightful lessons for other digital humanities projects considering the use of AR technology. A key takeaway is the comparative study of the two AR tracking methods, GPS and QR code, which can inform other researchers and developers about crucial factors in selecting AR tracking methods. These include user digital familiarity, the scale and conditions of target sites, and the developers’ technical capabilities, time, and budget constraints. Understanding users' digital familiarity is vital during the creation of user personas. Projects targeting users who are adept with the latest technologies might find a shorter learning curve and greater enthusiasm for novel AR tracking methods like GPS. Conversely, QR code tracking might be more suitable for projects with a diverse audience, as it's more widely recognized and easier to use. For instance, an AR project aimed at university students could potentially explore GPS tracking, considering their likely familiarity with advanced technologies. In contrast, a project targeting the broader local community, such as Durham's residents, might be better served by QR code tracking, given its broader accessibility and ease of use.

The second key factor in selecting AR tracking methods is the scale and conditions of the target site. GPS tracking is more effective in large, open outdoor areas, while QR Code tracking is better suited for smaller or indoor environments. For example, GPS tracking could be an ideal choice for a project at a spacious site like the Downtown Durham Historic Site. In contrast, QR Code tracking might be preferable in more confined spaces, such as museums. Another
consideration is the availability and ease of use of digital platforms that support these tracking methods. QR Code tracking is supported by many platforms in the market, which greatly simplifies the process of creating an AR experience. For instance, creating an interactive AR project on Model Viewer, an online platform, can be as straightforward as uploading a 3D digital model and generating a QR code with a few clicks. This ease of use makes QR Code tracking particularly appealing for projects with limited technical resources. On the other hand, GPS tracking is supported by fewer platforms, such as Vuforia, and often comes with more stringent licensing restrictions and potential fees. Additionally, these platforms may require more advanced technical and coding skills. Therefore, when selecting an AR tracking method, it's essential to consider the developers' technical expertise, the time available for project development, and budget constraints. These factors play a significant role in the ideation process of employing AR tracking technology in a project.

This thesis project's exploration of AR application at a historic site like Bennett Place yields insights into AR's value in such contexts. From a visitor's perspective, AR's novelty as an emerging technology holds a unique appeal, sparking interest in exploring historic sites. The study also demonstrates AR's capability in aiding visitors' understanding through the contextualization of historical information, visualization of restorations and reconstructions, and the employment of storytelling and gamification techniques. AR can provide contextual information about historic sites; for instance, pointing a smartphone at the Bennett House could reveal details about its history and significance. Furthermore, AR proves invaluable for visualizing restorations and reconstructions of historic sites. Visitors can view 3D models or images depicting these sites in their original states. For example, in this project, although the ash hopper and well have been removed, AR displays images of these original structures at their former locations, offering insights into Bennett Place's original layout and contrasting its current
state with its historical appearance. Additionally, AR, as a medium, allows interactive storytelling and gamification, enabling visitors to engage dynamically with historical narratives. This approach transforms visitors from passive observers to active participants, creating a more engaging and personalized experience. They gain control over their journey, focusing on areas of interest and bypassing fewer appealing sections. These interactive storytelling and gamification methods also open possibilities for presenting history from multiple viewpoints, allowing visitors to comprehend history's multifaceted nature and interpret it from their own perspectives.

From the standpoint of public historians, researchers, and developers, employing AR at historic sites is a cost-effective strategy compared to other digital projects, with a relatively low barrier in terms of technical skills. As previously discussed, numerous free platforms available today greatly simplify the AR creation process. This accessibility allows researchers to develop their own prototypes with minimal expense. In contrast, consider Virtual Reality (VR), which demands substantial efforts in environmental creation, including tasks like 3D modeling, and implementing lighting and shadows to craft an immersive virtual environment. AR, on the other hand, benefits from integrating virtual objects with the physical environment, thereby significantly reducing the time and effort required for environment construction. This efficiency makes AR a more accessible and practical choice for projects at historic sites, especially for teams with limited resources or technical expertise.

From the perspective of management organizations, particularly those at smaller historic sites, the application of AR presents notable economic and operational benefits. AR offers an innovative approach to publicity at historic sites, potentially increasing visitor numbers and broadening the demographic of target visitors. One key advantage is AR's ability to integrate features that allow visitors to easily share their experiences on social media, thereby promoting the site and attracting a younger audience. Additionally, AR has the potential to be a revenue-
generating tool. Even some historic sites, like Bennett Place, offer free admission, previous research indicated that visitors are willing to pay a fee for “upgrading” their visiting experience.\(^1\) This willingness can be leveraged by offering an AR-based tour or interactive experience for a fee. Besides, AR is an economically viable option for introducing interactive and engaging experiences at historic sites. Unlike VR, AR doesn’t require advanced equipment like headsets or controllers. Unlike Virtual Reality (VR), AR does not require advanced equipment like headsets or controllers. Most visitors’ mobile devices are already capable of supporting AR applications, which eliminates the need for additional investment in high-end technology. Furthermore, AR can serve as an alternative to traditional guided tours, potentially reducing the need for a large number of tour guides. This could lead to cost savings in terms of staff salaries. By offering a self-guided, interactive experience via AR, historic sites can maintain or even enhance visitor engagement while managing operational costs more effectively.

\textbf{5.3 Limitations}

During the development of this thesis project, it has to be noted that several limitations and restrictions exist when interpreting the result of this thesis project. The selection of highlighted locations in the AR experience is derived from the existing self-guided tour brochure at Bennett Place and this is a personal and subjective decision. The primary focus of these locations is on outdoor views, with limited attention to the interiors of historical structures. Visitors to Bennett Place have the opportunity to explore the interiors of most buildings, including the Bennett House, which is adorned with artifacts and objects that offer insights into

historical living conditions. The AR experience's exclusion of this information could potentially influence users' engagement and exploration of the site. Moreover, the natural trail within Bennett Place is another element that is not adequately represented in the Bennett Place AR application.

Additionally, the project's public accessibility is limited by licensing restrictions. The use of Vuforia as a development tool and NaturalReader for generating AI audio descriptions is subject to limitations. Vuforia’s license restricts commercial use and access to advanced features like GPS tracking, leading to a watermark being displayed on the screen. The AI-generated audio from NaturalReader is not permitted for public or commercial applications, further limiting the project's reach. As a result, to access the application, user testing participants must connect their mobile devices to my personal computer, which raises potential privacy concerns.

More limitations exist in the process of user testing. The participant pool is primarily composed of people around me, mostly from Duke University, which may not accurately reflect the diverse demographic of visitors to Bennett Place. Their similar backgrounds and experiences could influence the testing outcomes. Additionally, the limited number of participants and the project’s constrained time frame could impact the robustness and generalizability of the findings. These constraints should be considered when evaluating the AR's effectiveness in enhancing visitor’s experience at Bennett Place.

5.3 Future Directions

The rapid advancements in AR technology, both hardware and software, present exciting opportunities for future advancements and possibilities to this thesis project. For instance, Apple's announcement of its new mixed reality headset, Vision Pro, introduces innovative interaction modalities. Apple introduces it as a “spatial computer” with its new spatial operating system “visionOS” that enables users to interact with digital content using voice, eye movement and
minor hands movements, freeing users from traditional controllers.² As indicated by Apple, the visonOS provides an infinite spatial canvas for designers and developers to explore, experiment and rethink the experience in 3D. The new interactive method and operation system of Vision Pro provide more possibilities for AR developers when considering interaction design of their projects. While Vision Pro has not been released yet by the time this thesis project was developed, it is worthwhile considering new possibilities of implementing, advancing and incorporating this AR experience with the new operating system, experimenting with new interactive methods.

In the realm of authoring and development platforms, options like Adobe Aero offer intuitive development, viewing, and sharing of immersive mobile AR experiences. Aero, available on both desktop and mobile, doesn’t required coding knowledge and allows easy sharing of AR content. Aero’s compatibility with Geospatial Creator, which is powered by ARCore and the Google Maps Platform, allows developers to access and utilize its photorealistic 3D map databases. This integration could offer a more precise and user-friendly approach to implementing and exploring location-based AR experiences. This approach indicates another possibility for this project that allows the developer to preview and adjust digital content on a 3D digital map of Bennett Place, becoming an alternative for further development without extensive coding.

Due to the limited timeframe, the digital materials used in this thesis project were sourced from various places, resulting in a lack of uniform style and tone. Further development could include more extensive 3D modeling and animations, adding interactive elements in the AR

experience. Additionally, the app could implement more cohesive storytelling techniques in the descriptions and narratives. For instance, incorporating a first-person perspective, narrated as if by the Bennett Family, to recount the history and details of 19th-century life could foster a deeper emotional connection with visitors. This storytelling approach would personalize the experience, making the historical context more relatable and engaging by giving visitors a sense of stepping into the shoes of the Bennett Family, thus enhancing the overall impact of the tour. Additionally, introducing gamification elements, such as a reward system for visiting different locations or accessing various information segments, could increase engagement. A sharing feature enabling users to easily post screenshots or videos of Bennett Place with overlaid digital content to social media platforms would also enhance interaction and visitor’s engagement. This idea is inspired from an observation during the qualitative behavioral test, where a participant used another device to photograph the Unity Monument.

Beyond the AR technology and development, creating a comprehensive website or story map could significantly augment the project's reach and impact. Such a website will not be restricted by the authorship limitations of Vuforia and NaturalReader and can be distributed to a broader audience. It could weave together various content elements in the AR tour to deliver a cohesive narrative. Visitors who have experienced the AR tour could revisit and explore the content virtually, allowing for a deeper engagement and the opportunity to share the experience with others. The inclusion of interactive features like a comment section could allow direct user feedback, contributing to further refinement of the AR experience. The proposed website could also serve as a robust resource for other researchers and developers. Acting as a digital archive, it could be enriched with external links to more authoritative sources, media, documentation of the user testing process, findings from the ISS lab, and immersive 360-degree photographs of Bennett
Place. This comprehensive repository of information could foster a collaborative ecosystem for ongoing research and development.

Moreover, the potential to share the Unity project and other resources used in this thesis on the website could transform this work into an open-source initiative. This transformation could catalyze collaborative enhancements, drawing insights and contributions from a global community of developers and researchers. This digital project can provide a template for other researchers and developers to be applied at more historic sites like Bennett Place, facilitating the exploration of AR application in public history projects.
6. Conclusion

Should user experience design be included as part of the design and development process in digital humanity projects? In recent years, user experience design (UX design) has been a heated topic and has been applied in a myriad of fields. In 2016, Brennan suggested an intersection area of digital humanities and public history, public digital humanities, which utilizes various digital technological tools to facilitate user experience and address their needs. It identifies the public as the primary audience in digital humanities projects, pointing out the necessity of understanding the public’s interests, agendas and needs, incorporating their voices and employing UX design techniques in digital humanity projects.

Augmented reality (AR) is one of the common digital technological tools that has been extensively researched in the digital humanities field and has been widely applied at museums and tourist sites for its ability to enhance visitor’s experience and deliver historic and humanistic information. AR can be used as a tool to experiment the inclusion of UX design in digital humanities projects. This thesis project explores several techniques of UX design, including UX design flow, UX evaluation method and user testing, and uses them as a guideline in development of the digital project. This thesis project follows a common UX design flow with four major phases: research, wireframing and ideations, design, and user testing. The research phase investigates contextual information about the selected site, Bennett Place, its current situation, and visitor personas, providing a comprehensive view of the design objectives and user’s expectations. The ideations phase presents the decision process of content design and technology selection in the digital project. Content design includes a three-level structure information design, aiming to effectively present information that users are interested in, while technology selection indicates that different AR tracking technology will provide a different experience. The next
phase reveals details of implementation of the digital project, and the last phase conducts user
testing. It uses UX design principles to evaluate the digital AR project at Bennett Place and
provides insights about the effectiveness of application of AR in the public digital humanities
field. While the testing outcomes don't offer a definitive assessment of the AR experience, the
user testing conducted within this thesis project yields important lessons on designing, executing
and evaluating user testing for other public digital humanities projects. By borrowing the UX
design techniques, this thesis project not only provides an interactive, engaging, and informative
experience to visitors at Bennett Place, but also shows the possibilities of incorporating UX
design as part of digital humanities projects and putting focus on the role of the audience in
digital humanities projects.

AR stands at a pivotal point in its evolution. While it has been a topic of interest for
several years, we are only beginning to scratch the surface of its potential. This thesis, with its
focus on AR from a UX perspective, offers a valuable lens through which to understand the
future of this technology. Looking ahead, the integration of AR into daily life is expected to
transform how we interact with the world around us. As technology continues to evolve, it is
crucial to approach its development with a thoughtful, user-centric perspective. The exploration
undertaken in this thesis is just the beginning, serving as a foundation for the exciting journey
ahead in the realm of augmented reality.
Appendix A: Illustrations

Figure 1: An illustration simulates the design of “Experiencing Civil War History Through Augmented Reality” project at Pamplin Historical Park.¹

Figure 2: Initial screen of the application “Once Up a Time in Dispilio.”²

¹ Retrieved from https://civilwar.vt.edu/experiencing-civil-war-history-through-augmented-reality/.
Figure 3: Initial Screen of the application "Crime in the Lake Settlement."³

Figure 4: Navigation map of “Once Up a Time in Dispilio.”⁴

³ Kleftodimos et al., 31.
⁴ Kleftodimos et al., 29.
Figure 5: Screen of a multiple-choice question in “Once Up a Time in Dispilio.”

Figure 6: Screen of the puzzle pieces completed in “Once Up a Time in Dispilio.”

Kleftodimos et al., 29.
Kleftodimos et al., 30.
Figure 7: Screen of a message to the player in “Crime in the Lake Settlement.”

Figure 8: Proposed model integrating Scrum development with UX workflow.

7 Kleftodimos et al., 33.
Figure 9: UX Honeycomb Framework.


Figure 10: Scan of Bennett Place self-guided tour brochure (front).
Figure 11: Scan of Bennett Place self-guided tour brochure (back).

Figure 12: Bennett Place AR App’s wireframe of Welcome Page (Prototyping in Figma).
Figure 13: Bennett Place AR App’s AR Tour wireframe (Prototyping in Figma).
Figure 14: Drawing of Meeting of the two Generals.\textsuperscript{10}

Figure 15: Photo of the Ash Hopper at Bennett Place.\textsuperscript{11}

\textsuperscript{10} Bradley, \textit{This Astounding Close}, 176.

\textsuperscript{11} Retrieved from https://www.dwhike.com/History/Civil-War/Bennett-Place-NC/i-T6wWWTG.
These models were purchased and downloaded from Sketchfab, an online model asset store. The aim of using these models is to represent the look of the Bennett Family’s kitchen garden.

Figure 18: Screenshot of Vuforia Developer Portal, showing License Key this thesis project used.

Figure 19: Screenshot of Vuforia Target Manager and Image Target Database.\textsuperscript{14}

\textsuperscript{14} The “Rating” of 5 stars indicates that these QR codes enable best detection and tracking performance from the Vuforia Engine.
Figure 20: Screenshot of UI function in Unity.

Figure 21: Screenshot of C# Code for 3-level AR tour structure in Unity.
Figure 22: Screenshot of Vuforia Configuration Inspector in Unity (QRCode-based Project).

Figure 23: Screenshot of Image Target Inspector (QRCode-based Project).
Figure 24: Screenshot of Spot “Hillsborough Road” Inspector in Unity (GPS-based Project).

Figure 25: Screenshot of Hierarchy in Unity (GPS-based Project).
Figure 26: Screenshot of Hotspot Setting in Unity (GPS-based Project).

Figure 27: Screenshot of Player Setting in Unity.
Figure 28: The welcome screen of the application in both versions.
The American Civil War (1861-1865) stands as a pivotal moment in U.S. history, a conflict ignited by deep-seated divisions over states' rights, economic interests, and, centrally, the institution of slavery. The war saw the Northern states (the Union) clashing with the Southern states (the Confederacy) who sought independence to preserve their way of life, including the continuation of slavery. As battles raged from vast fields to small towns, families were often torn apart by their loyalties. President Abraham Lincoln's Emancipation Proclamation in 1863 declared freedom for slaves in Confederate-held territories, adding moral weight to the Union's cause. The war's toll was immense, resulting in over 600,000 casualties. Its conclusion marked the abolition of slavery and set the stage for the challenging era of Reconstruction. Bennett Place, where you stand, played a crucial role in the war's denouement, symbolizing the nation's first steps toward healing and unity.

Figure 29: The “About Civil War” page.
James and Nancy Bennett are an example of a typical family living in America at the time of the American Civil War. Average middle-class families were considered at that time to be “yeoman farmers,” farmers who owned small acreages, working the land themselves, and providing for themselves through their skills of sewing, making and repairing tools, and other aspects of self-sufficiency. The Bennett Family never owned slaves as this was a very expensive business endeavor. Less than 20% of the American population could afford to enter into this type of agricultural economic structure. James and Nancy had three children, Lorenzo Leigh, Eliza Ann, and Alphonzo Jackson. All grew to adulthood. When the American Civil War erupted in April 1861, the Bennett family was reluctant to get involved in the conflict. They owned no slaves, and much of central North Carolina had voted secession down. However, on May 12, 1862, Lorenzo answered the call enlisting in the 27th North Carolina Infantry. Company G out of the neighboring town of Hillsborough. It was not long after his regiment went to Virginia that he died of typhoid pneumonia in October 1862 in a Confederate Army hospital in Winchester, Virginia. He is buried in the Mount Hebron Cemetery in Winchester, Virginia. Alphonzo, who is believed to have remained on the homestead during the war also died in 1862. It is unknown as to where he is buried. Perhaps in the Bennett Family Cemetery on the Bennett Family property. Research continues on his personal background. Eliza married a local fellow named Robert Duke, who went off to war. During the time Eliza remained home with her parents. She was with her parents at the farm when General Johnston and Major General Sherman met at their home. Following the war, her mother and she made efforts to maintain the family farm. However, with the passing of James, the women moved to what was then becoming the thriving tobacco city of Durham. She is buried in Maplewood Cemetery in Durham, North Carolina. As for James and Nancy, after the war, they tried to rebuild their lives through the period of Reconstruction. Life was even more challenging for the Bennett family as the years passed and one by one James and Nancy died. James died in 1887, and Nancy followed in 1891. The Bennett family was no longer capable of maintaining the farm with her daughter. It is believed that James and Nancy are buried in their family cemetery. Preservation work of the family cemetery is still in progress. Source: http://www.bennettplacehistoricalsociety.com/history/bennett-family.
Figure 31: The “Map” page.
Figure 32: The initial interface of the “AR Tour” page in the GPS version (screenshot of testing recording at Bennett Place).
Figure 33: The first level content of “Bandstand” triggered in the “AR Tour” page (screenshot of testing recording at Bennett Place).
Figure 34: The “Text Description” page of “Bandstand” (screenshot of testing recording at Bennett Place).
Figure 35: The second level content of “Bandstand” (screenshot of testing recording at Bennett Place).
Figure 36: The third level content of “Bandstand” (an external website opened in Safari).
Figure 37: A user scanning the QR code at “Hillsborough Road” (screenshot of testing recording at Bennett Place).
Figure 38: A photo of the GPS user looking around at Hillsborough Road.

Figure 39: A photo of the GPS user taking a picture of the Unity Monument.
Figure 40: The design of brochure for the QR code version of user test.

Figure 41: The QR code user scanning the marker at “Hillsborough Road”.
Figure 42: Timeline of each iteration and user testing.

Figure 43: Screenshot of Iteration 3, showing title of location at the bottom of the screen.
Figure 44: Screenshot of C# codes (QR Code) that controls placement of images and QR codes.

```csharp
our_ShowObj = QR_codeObj;
if (showImage[index - 1] != null)
{
    QR_codeObj.SetActive(true);
    QR_codeObj.transform.position = new Vector3(0, 0, 3);
    QR_codeObj.GetComponentInChildren<Image>().sprite = showImage[index - 1];
    QR_codeObj.transform.Find("Video").gameObject.SetActive(false);
}
else
{
    QR_codeObj.SetActive(false);
}
```

Figure 45: Map at Welcome Page (QR Code Version).
Figure 46: Map at Welcome Page (GPS Version).
Figure 47: Screenshot of project website in ArcGIS StoryMap.

```csharp
void SetImageSize(Sprite s)
{
    cur_Shown.transform.localScale = new Vector3(0.005f, 0.005f, 0.005f);
    cur_Shown.transform.localScale = new Vector3(s.texture.width, s.texture.height);
}
```

Figure 48: C# codes that controls image size and ratio.
Figure 49: Screenshot of "My Map" embedded in the AR tour page.
Appendix B: Digital Content Details

This appendix presents the details of content presented, including descriptions, digital materials, and links to external websites, during the AR experience at each location.

Table 3: Digital content at "Hillsborough Road."

<table>
<thead>
<tr>
<th>Spot 1: Hillsborough Road</th>
<th>Description</th>
<th>Digital Media</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual Description</strong></td>
<td>The roadbed before you trace the path of the historic Hillsborough Road, connecting the towns of Hillsborough in the west to Raleigh in the east. It was along this very route that General Joseph E. Johnston of the Confederacy and General William Tecumseh Sherman of the Union journeyed to their fateful meeting at the Bennett Farm in April 1865. The drawing depicts the meeting of Sherman and Johnston.¹⁵</td>
<td><img src="image" alt="Figure 50: Historic image at &quot;Hillsborough Road.&quot;" /></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>The Bennett family used to sell items from their farm to travelers on this road and also take guests into their home, offering them a place to stay and meals for a fee, much like a small inn along this Hillsborough Road. Their home unexpectedly became a historic site during the Civil War. The mystery of how this happened is still debated. Some say the location was chosen on purpose, while others believe it was a chance meeting. Picture this: two generals from opposing sides, Johnston and Sherman, met on the Hillsboro Road, both waving white flags. Johnston suggested to Hampton that they meet at a farmhouse that Johnston had just passed, and Sherman agreed. The</td>
<td>N/A</td>
</tr>
</tbody>
</table>

¹⁵ This is retrieved from the original Bennett Place self-guided walking tour.
¹⁶ Bradley, *This Astounding Close*, 176.
Bennett family, who had lost their sons during the war time, suddenly found their home at the center of a historic event. There is no direct record of how the Bennett Family felt about this. However, during this AR experience, you can step into their shoes, feeling the mix of emotions as history unfolded in their own backyard.¹⁷

| External Resources | For more information about history: North Carolina Lives and Legacies: Bennett Place Project - Story¹⁸ | N/A |

¹⁷ “BENNETT PLACE | Open Durham.”
¹⁸ Link to: https://sites.duke.edu/project_002_001_bennett_place_project/summer2023/bennett-place-project-story/.
# Table 4: Digital content at "Morgen Bench."

<table>
<thead>
<tr>
<th>Spot 2: Morgen Bench</th>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual Description</strong></td>
<td>This bench honors Mrs. Sarah T. Morgan, wife of Samuel T. Morgan, who together purchased 30.8 acres of Bennett Place land from the Duke Land and Improvement Corporation. They transformed the land to create Bennett Place Memorial Park. The image shows a portrait of Samuel T. Morgan.(^{19})</td>
<td><img src="image" alt="Figure 51: Historic image at &quot;Morgen Bench.&quot;(^{20})" /></td>
<td></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>After the war, the Bennett farm went through several changes in ownership. The Bennett family kept the farm until the 1880s. In 1890, Brodie Duke, a new owner, tried and failed to sell the farmhouse as a historic piece at the 1893 Chicago Exposition. Later, Samuel T. Morgan, who started the Durham Fertilizer Company, owned the farm and also tried to promote it as a historic site.(^{21})</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td><strong>External Resources</strong></td>
<td>More information about Samuel T. Morgan: NCPdia - Samuel T. Morgan.(^{22})</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

---

\(^{19}\) This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.

\(^{20}\) Image retrieved from Courtesy Duke Rare Book and Manuscript Collection, via Museum of Durham History.

\(^{21}\) “BENNETT PLACE | Open Durham.”

\(^{22}\) Link to: [https://www.ncpedia.org/biography/morgan-samuel-tate](https://www.ncpedia.org/biography/morgan-samuel-tate).
Table 5: Digital content at "Well with Sweep."

<table>
<thead>
<tr>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual Description</strong></td>
<td>This well was originally hand dug and manually lined with stone. The reconstructed box and sweep protect the well. This is an 1881 drawing, titled Carolina Home, depicting a woman pouring water from a bucket suspended from a well sweep. This drawing indicates how the well with sweep was used in the 19th century.</td>
<td><img src="image" alt="Figure 52: Historic image at &quot;Well with Sweep.&quot;" /></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>The Bennett family farm relied on this well to provide for their livelihoods. The well sweep was a simple device used in 19th-century North Carolina to draw water from wells without ropes or pulleys. It required only wooden poles for construction. A vertical post by the well held a horizontal pole (sweep) with a heavier end resting on the ground. A thinner pole with a bucket was on the other end. To fetch water, one would pull the thin pole down into the well, fill the bucket, and the sweep's weight would lift it up. Over time, well sweeps were replaced by pulleys, cranks, and later, mechanical pumps. They became rare by mid-20th century.</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>External Resources</strong></td>
<td>For more information about Well with Sweep: What is a well sweep and how does it work?</td>
<td>N/A</td>
</tr>
</tbody>
</table>

23 This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.
24 Image retrieved from North Carolina Collection, University of North Carolina at Chapel Hill Library.
26 Link to: https://madisonbarns.wordpress.com/2015/06/27/what-is-a-well-sweep-and-how-does-it-work/.

111
Table 6: Digital Content at "Bennett House."

<table>
<thead>
<tr>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual Description</strong></td>
<td>The Bennett house was where the famous scene of Johnston's final surrender took place on April 26, 1865. The original Bennett house was destroyed by fire in 1921. The house that stands here today was a condemned house, built about 1840, about the same age, size, and interior arrangement as the Bennett house was discovered in the vicinity. It was acquired and moved to the site for restoration in 1962. This is a drawing depicting the negotiation between Sherman and Johnston in the Bennett farmhouse and revealing the interior of the Bennett House. The photo shows the Bennett House in serious disrepair in the early 20th century.</td>
<td></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>The Bennett house was home to James Bennett, his wife Nancy, and their three children. They were a typical middle-class family during the American Civil War, known as &quot;yeoman&quot; farmers. They owned a small farm, worked the land themselves, and were self-sufficient, skilled in sewing and repairing tools. Their children, Lorenzo Leigh, Eliza Ann, and Alphonzo Jackson, all grew to adulthood. The family was hesitant to join the war. Lorenzo and Alphonzo sadly passed away in 1862 during the war time. Eliza, their daughter, stayed with her parents at the Bennett farm during the Civil War. On April 17th, 1865, the two</td>
<td></td>
</tr>
</tbody>
</table>

---

27 Powell, “Bennett Place | NCpedia,” NCPedia.
28 Bradley, *This Astounding Close*, 176.
30 Image retrieved from Courtesy Durham County Library / North Carolina Collection.
generals entered the yard of the Bennetts and asked permission of Nancy and James Bennett to use the house. From General Sherman’s description, the Bennetts kept their house very clean and neat, with floors scrubbed to a milky whiteness. The furniture in the room was arranged with neatness and taste.\textsuperscript{29}

| External Resources | More information about Surrender Negotiations: Bennett Place Historic Site - History - Surrender Negotiation. \textsuperscript{31} | N/A |

\textsuperscript{29} Menius, “James Bennitt,” 305–26.

\textsuperscript{31} Link to: http://www.bennetplacehistoricsite.com/history/surrender-negotiations/.
Table 7: Digital Content at "Kitchen House."

<table>
<thead>
<tr>
<th>Spot 5: Kitchen House</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Level</strong></td>
<td><strong>Description</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Factual Description** | Destroyed in the fire in 1921 along with the farmhouse, the kitchen house was also reconstructed in 1962. You can see that this is a photo of Bennett Place, looking northwest from Hillsboro Road in 1910. At the right of the image, you can see the original Kitchen House.  

**Figure 55: Historic image at "Kitchen House."**

| **Humanistic Narrative** | The kitchen house, also known as a detached kitchen which few families could afford in the 19th century, was kept separate from the house, because the frequent fires and heat from constant cooking makes it hot, smoky, and smelly. The Bennett family retired to this kitchen house during the surrender negotiations. The kitchen in the 19th century North Carolina was a hub of family activity centered around meal preparation. Cooking was labor-intensive, dominating the average housewife's time. Meals were prepared on the hearth of brick fireplaces, using cast-iron Dutch ovens. Food preservation was crucial, employing drying, salting, and smoking methods. Manual tools like mortars and pestles were used for grinding spices. Families were largely self-sufficient, growing and processing their own food, with  

**Figure 56: Second image at "Kitchen House," about cooking in the 1800s.** |

---

32 This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.

33 Image retrieved from Courtesy Durham County Library / North Carolina Collection.

35 Image retrieved from YouTube video: Cooking Dinner 200 Years Ago, https://www.youtube.com/watch?v=WHipdvDT77A.
meal preparation and consumption being central to daily life.\textsuperscript{34}

| External Resources | More information about Cooking in the 1800s: NCPdia - Cooking in the 1800s\textsuperscript{36}  
| Video of the process of making dinner in the 1800s: Cooking Dinner 200 Years Ago - 1800s America – Summer.\textsuperscript{37} | N/A |


\textsuperscript{36} Link to: https://www.ncpedia.org/culture/food/cooking-in-the-1800s.

\textsuperscript{37} Link to: https://www.youtube.com/watch?v=WHipdvDtt77A.
### Table 8: Digital Content at "Dairy House."

<table>
<thead>
<tr>
<th>Spot 6: Dairy House</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual Description</strong></td>
<td>This dairy house was used to store dairy products such as butter, cream and cheese. The clay floor keeps the building cooler in all seasons, especially in summer so the families can store ice which provides additional cooling. This image, called Mountain Milk Maids, depicts the dairy work in the 19th century.(^\text{38})</td>
<td><img src="image1" alt="Figure 57: Historic image at &quot;Dairy House.&quot;(^\text{39})" /></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>The Bennetts were very good at caring cattles compared to their contemporaries, some of whom were forced to buy butter despite owning a half-dozen bovines. The average farmer who allowed his herd to run wild produced only 19 pounds of butter per cow in 1849, but the Bennetts churned 150 pounds from only 3 milk cows. Their well-cared-for cattle were probably larger than the typical southern cow of that time, which weighed 500 to 700 pounds.(^\text{40})</td>
<td><img src="image2" alt="Figure 58: Screenshot of the model at &quot;Dairy House.&quot;" /></td>
</tr>
<tr>
<td><strong>External Resources</strong></td>
<td>For more information about dairy industry: The American Dairy Industry Video of early dairy history and the process of making butter: Early American Dairy</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

\(^{38}\) This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.  
\(^{39}\) Image retrieved from Universal History Archive/Universal Images Group via Getty Images.  
Table 9: Digital content at "Smoke House."

<table>
<thead>
<tr>
<th>Spot 7: Smoke House</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Level</strong></td>
<td><strong>Description</strong></td>
<td><strong>Digital Content</strong></td>
</tr>
<tr>
<td>Factual Description</td>
<td>This small log building is a representation of the original smokehouse which stood on this location. This building was reconstructed in the 1960's using materials from the Proctor house. This sketch illustrates the interior of a smokehouse in the 19th century and reveals one possible way to smoke meat.</td>
<td><img src="image" alt="Figure 59: Historic image at &quot;Smoke House.&quot;" /></td>
</tr>
<tr>
<td>Humanistic Narrative</td>
<td>The smoke house was used by the family to cure meat as well as store it along with gathered vegetables and food supplies.</td>
<td><img src="image" alt="Figure 60: Screenshot of the model at &quot;Smoke House.&quot;" /></td>
</tr>
</tbody>
</table>

---

41 This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.
42 Image retrieved from Stock Illustration | Smokehouse in Getty Image.
43 This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.
<table>
<thead>
<tr>
<th>External Resources</th>
<th>For more information about Smokehouse: NCPedia – Smokehouses. Video of how the smokehouse was use in the 1800s: Dan Conboy: 1800s Smoke House - How it was used by Pioneers.</th>
<th>N/A</th>
</tr>
</thead>
</table>

44 Link to: https://www.ncpedia.org/smokehouses.
45 Link to: https://www.youtube.com/watch?v=XTcUqiPLXM.
Table 10: Digital content at "Ash Hopper."

<table>
<thead>
<tr>
<th>Spot 8: Ash Hopper</th>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>Description</td>
<td>This is a similar structure held ashes from the fireplace, which were combined with water through a pour and boil process to make potash, an ingredient for soap, hominy, and paint. 46</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 61: Historic image at "Ash Hopper." 47](image1)

<table>
<thead>
<tr>
<th>Humanistic Narrative</th>
<th>Description</th>
<th>For more information about Ash Hopper: Using Lye: Ash Hopper. 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the 1800s, families made soap at home using fat, potash or lye, and water. Soap making is often considered as women’s job and they made soap annually or semiannually. They converted ashes to lye using an ash hopper. This tool held ashes, and water was poured over them to collect lye. The ingredients were then combined in a large vessel to create soap for bathing, laundry, and dishes. 48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 62: Second image at "Ash Hopper," about soap making. 49](image2)

<table>
<thead>
<tr>
<th>External Resources</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>For more information about Ash Hopper: Using Lye: Ash Hopper. 50</td>
<td></td>
</tr>
</tbody>
</table>

46 This is retrieved from the original Bennett Place self-guided walking tour.
47 Image retrieved from https://www.dwhike.com/History/Civil-War/Bennett-Place-NC/t-T6wWWTG.
49 Avinger, “Soap in America.”
50 Link to: https://thelibrary.org/lochist/periodicals/bittersweet/sp74h.htm.
<table>
<thead>
<tr>
<th>For more information about Soap Making: Soap in America: A Brief History. 51</th>
</tr>
</thead>
</table>

Table 11: Digital content at "Kitchen Garden."

<table>
<thead>
<tr>
<th>Spot 9: Kitchen Garden</th>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factual Description</td>
<td>This is where the family grew vegetables and herbs for cooking and medicine. The image shows a typical arrangement of plant materials within the kitchen garden.</td>
<td><img src="image" alt="Figure 63: Historic image at &quot;Kitchen Garden.&quot;" /></td>
</tr>
<tr>
<td></td>
<td>Humanistic Narrative</td>
<td>Family gardens like this were usually tended by the farm’s women. These gardens weren't always well-kept because there were plenty of wild fruits around, and people didn’t fully realize how good vegetables were for their health. The farm women, burdened with many tasks, probably had little time to devote to the gardens. Still, they grew and sold various crops at their family gardens like cucumbers, onions, potatoes, squash, turnips, cherries and apples.</td>
<td><img src="image" alt="Figure 64: Screenshot of the model at &quot;Kitchen Garden.&quot;" /></td>
</tr>
<tr>
<td>External Resources</td>
<td>For more information about plants in Bennett Place: Charlotte Joyner's Storymap: Chronicling Corn.</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

52 This is retrieved from the original Bennett Place self-guided walking tour.
53 Image retrieved from: Batty Langley, “All the Geometrical Diagrams of the Problems contain’d in the first Part,” in New Principles of Gardening (1728), pl. I.
55 Link to: https://storymaps.arcgis.com/stories/bd6bf65f3acb47db8ca34b05907bbe09.
<table>
<thead>
<tr>
<th>Spot 10: Bandstand</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information Level</strong></td>
<td><strong>Description</strong></td>
<td><strong>Digital Content</strong></td>
</tr>
<tr>
<td><strong>Factual Description</strong></td>
<td>The gazebo was erected in 1916 for the Durham Rotary Club as a venue for ceremonies and concerts. It was almost torn down due to downtown development plans, but the Rotary Club had it moved to Bennett Place to enhance the Memorial Park. The image shows this bandstand in the original Rotary Park in 1916.(^{56})</td>
<td><img src="image" alt="Figure 65: Historic image at &quot;Bandstand.&quot;" /></td>
</tr>
<tr>
<td><strong>Humanistic Narrative</strong></td>
<td>Even though the bandstand was moved here later, music was a part of the Bennett family’s life. A tune book was found in James Bennett’s collection. This book mainly contains religious songs, likely reflecting a Methodist faith. It also serves as an educational tool with initial pages teaching basic music theory. The tunes are often presented as two-line snippets with sometimes mismatched musical notation. The exact relationship between James Bennett and this book is unclear, it’s speculated that it might have served as a teaching manual possibly for his grandchildren. The image shows page 7 from James Bennett’ tune book.(^{57})</td>
<td><img src="image" alt="Figure 66: Second image at &quot;Bandstand,&quot; about a tune book of the Bennett Family." /></td>
</tr>
<tr>
<td><strong>External Resources</strong></td>
<td>For more information about Bandstand: Open Durham - ROTARY CLUB BANDSTAND. (^{59})</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

\(^{56}\) This is retrieved from the original Bennett Place self-guided walking tour, edited by ISS Lab.


\(^{58}\) Image retrieved from: Ruth Player, “The Sound of Music or the Sound of Music?,” ArcGIS Story Map.

\(^{59}\) Link to: https://www.opendurham.org/objects/rotary-club-bandstand.
Table 13: Digital content at "Unity Monument."

<table>
<thead>
<tr>
<th>Information Level</th>
<th>Description</th>
<th>Digital Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual Description</td>
<td>Two white Corinthian columns, one representing the Confederacy and the other representing the Union, are joined by a single top crosspiece. This monument symbolizes the country's reunification after the American Civil War. In 1923, it was erected and dedicated by the Morgan family. Julian Carr and Bennehan Cameron officiated at the ceremony, and despite the protests of the United Daughters of the Confederacy to 'General' Carr, he struck a tone of unanimity, saying &quot;There is no North; there is no South... one section responds as the other when the national safety is threatened.&quot; The photo shows the Dedication of the Unity Monument. Carr is visible near the center of the crowd, speaking at the dedication of the Unity Monument at Bennett Place in 1923.</td>
<td></td>
</tr>
<tr>
<td>Humanistic Narrative</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>External Resources</td>
<td>For more information about Unity Monument: North Carolina Lives and Legacies: Bennett Place Project - Story</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

60 “BENNETT PLACE | Open Durham.”
61 Image retrieved from Courtesy Duke Rare Book and Manuscript Collection - Wyatt Dixon Collection.
Appendix C: Qualitative Behavioral User Testing Notes

Test 1: Bennett Place AR App (GPS Version)

Time: Nov. 4th, 2023  3PM

Participant Name: Mia Du

Bio: MAE at Duke University

Experience time duration: 14 mins

Documentation Notes:

The user didn’t have previous knowledge about Bennett Place. She was informed that this application uses GPS location for activating information and it does not require her action.

She started by clicking “Civil War History” and “About Bennett Family,” but she didn’t read closely. She went directly to the site.

She didn’t return to the main menu and didn’t click the AR tour until she reached “Hillsborough Road.” When the audio indicator triggered, she realized she should check the app. She went back to the main menu and got to the “AR Tour” page. Part 1 audio description successfully triggered. She didn’t notice the image at “Hillsborough Road.” She clicked at “Text Description,” but didn’t read through. Then, she clicked “More information,” successfully triggering part 2 audio description.

Then, she moved to the next spot, “Unity Monument.” Audio description was successfully triggered. She noticed the image. She took a picture of the Unity Monument. She clicked “More Information,” but she didn’t check external links.

From Unity Monument, she went directly to “Bennett House”. Audio descriptions were successfully triggered for both part 1 and part 2. She noticed the image. Then, she went inside of the Bennett House.
Then, she moved to Kitchen House. Audio descriptions and digital content for both part 1 and part 2 were successfully triggered.

She went to “Smoke House.” Information for both part 1 and part 2 were successfully triggered.

She didn’t reach the area around “Ash Hopper” and “Kitchen Garden.”

She then moved to “Dairy House.” Part 1 information was triggered, but she didn’t finish all the information. She didn’t went through part 2 information.

She was a little bit lost and confused after “Dairy House,” but she didn’t check the map. She found “Bandstand” very soon and went toward it. On the way, she passed “Well with Sweep” and the audio description and image about “Well with Sweep” was surprisingly triggered. She stopped at “Well with Sweep” shortly and listened to part 1 audio description.

After “Well with Sweep,” She reached “Bandstand.” Information for both part 1 and part 2 was triggered.

The last spot she reached was “Morgan Bench.” She only listened to part 1 audio description.

She didn’t check the map throughout the experience.

She didn’t check part 3 external links throughout the experience.
Test 2: Bennett Place AR App (QR Code Version)

Time: Nov. 4th, 2023  3:30 PM

Participant Name: Will S.

Bio: MA at Duke University

Experience time: 21 mins

Documentation Notes:

The user does not have previous knowledge about Bennett Place. He was informed that this application uses QR codes to activate information.

Since the permission of Bennett Place management team is required to place QR codes on site, this test used a specially designed brochure with a map and 11 QR codes to assist the AR tour.

He didn’t check “About Bennett Family” and “Civil War History” and started the AR experience directly.

He went to “Hillsborough Road” first, as it’s indicated on the map. He successfully scanned the QR code on the spot. He clicked “More Information” when the part 1 audio was not finished, triggering part 2 audio description. He was a little bit confused and checked “Text Description.” He didn’t check part 3 external links.

He then went to “Unity Monument.” He only reached part 1 information.

The next spot was “Bennett House.” He checked all of part 1, part 2 and part 3 information and clicked the external links in part 3. However, he didn’t spend time reading this. He didn’t get inside of Bennett House.

Then he went to “Smoke House.” He checked both part 1 and part 2 information by clicking the “More Information” button.

The next spot was “Kitchen House.” He checked both part 1 and part 2 information.
He went to “Kitchen Garden.” He checked both part 1 and part 2 information. Additionally, he checked “Text Description” and checked part 3 information.

At the same location, he scanned “Ash Hopper,” because they were close. He intentionally left and only looked at part 1 information.

He went to “Dairy House” and checked both part 1 and part 2 information.

He followed the map and went to “Bandstand.” He checked both part 1 and part 2 information.

He went to “Well with Sweep.” He checked both part 1 and part 2 information.

He went to “Morgan Bench.” He checked both part 1 and part 2 information.

He was able to understand the application quickly.

With the map, he didn’t miss any spot.
Appendix D: Qualitative Behavioral User Testing Survey

During the quantitative attitudinal testing, a survey form with two versions (GPS and QR code version) is designed for the Bennett Place AR app. This thesis project used Google Forms to design and distribute surveys. This appendix shows the questions design of the survey.

Figure 68: Quantitative attitudinal test survey (both versions), Part 1.

62 Link to GPS version Survey: https://forms.gle/Xgfc3aarjsdqHDsi6; link to QR code version survey: https://forms.gle/Y33Nwqcu8VvUdx76.
Figure 69: Quantitative attitudinal test survey (both versions), Part 2.
Figure 70: Quantitative attitudinal test survey (both versions), Part 2 (continue).
Figure 71: Quantitative attitudinal test survey (both versions), Part 3.
Figure 72: Quantitative attitudinal test survey, Part 4 (GPS version).
Figure 73: Quantitative attitudinal test survey, Part 4 (QR code version).
Bibliography


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