Happy Traveler: Discovering Joy on University Campuses and Beyond Through a Web-Based GIS Application

by

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Dedication

To my family and friends, who have supported me through the fog and the forests.

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Abbreviations

AMD	Asynchronous module definition
CDN	Content delivery network
APA	American Psychological Association
AGOL	ArcGIS Online
BIPOC	Black, indigenous, and people of color
CMHWB	Community mental health and well-being
CSS	Cascading Style Sheets
DRM	Day reconstruction method
EMA	Ecological momentary assessment
FS	Flourishing Scale
GIS	Geographic information system
GPS	Global Positioning System
HTML	Hyper Text Markup Language
HTTPS	Hypertext Transfer Protocol Secured
ID	Identification number
IP	Internet Protocol
IRB	Internal Review Board
JSON	JavaScript Object Notation
LSRG	Lyft Safe Ride Geofence
PANAS	Positive and Negative Affect Schedule
PHSR	Post hoc self-reporting
PPGIS	Public participatory GIS

REST	Representational state transfer
SaaS	Software-as-a-Service
SJS	State Joy Scale
SSI	Spatial Sciences Institute
SWIS	Student Well-being Index Survey
URL	Uniform resource locator
USC	University of Southern California
USCT	University of Southern California Transportation
UPC	University Park Campus
VGI	Volunteered geographic information
WBC	Well-Being Collective
WYSIWYG	What-you-see-is-what-you-get

Abstract

Students returning to university and college campuses amid a global pandemic, political unrest, and a rapidly changing climate, are at an increased risk of mental health challenges like anxiety and depression (Berry et al. 2018; Gao et al. 2020). During this period of turmoil and beyond, individuals on and around school campuses will likely want and need spaces where they can experience joy. Mental health and well-being are crucial facets of overall health. When these issues are not addressed or treated, the ill effects can impact lives, proliferate into communities, and negatively affect academic performance, retention, and graduation rates. Conversely, research has shown that reflecting and sharing positive experiences can increase positive affect, happiness, and life satisfaction (Lambert et al. 2013). The objective of this thesis is to develop a community-centered Web GIS application that lets users map places where they experience joy using an online cloud-based GIS platform to create an intuitive crowdsourcing interface. This study focused on a region encompassing the University of Southern California's University Park campus (USC UPC) and used USC community members to beta test the application and determine limitations and future improvements to the user interface, application workflow, and functionality. The application enables students, staff, faculty, and other community members to record their state of well-being and experiences of joy at different geographic locations and to observe the perceptions of joy and well-being of others around campus. University planners and university mental health professionals can utilize this data to make better decisions regarding mental health programs, campus design, and student outreach and education. Beta testing and feedback revealed that future work includes improving the database and storage, reaching out to stakeholders to involve them in the design, and continuing to customize and develop *Happy Traveler* with additional developers.

Chapter 1 Introduction

During our lives, we often work, study, and toil in the pursuit of one of the most sought-after, and elusive emotions, joy. The pervasiveness of technology and social media has made it easier to seek moments of joy and connect with others from a distance, yet these mechanisms have also been correlated with a surge of consequences like lower academic performance, addiction to instant gratification, comparison, depression, and anxiety (LaRose et al. 2014; Dhir et al. 2018). University campuses are environments where many individuals seek joy but experience those damaging effects that thrive due to factors like academic rigor, new surroundings, and social competition. However, with well-planned resources and preparation, university campuses can be spaces that successfully allow their communities to mitigate negative outcomes and instead, cultivate joy, good mental health, life-long relationships, strong individuals, and powerful ideas. Understanding the source of community joy on a university campus could be crucial for effectively changing the community culture around mental health and cultivating healthy individuals. Academics have used web and mobile geographic information systems/science (GIS) and crowdsourcing methods for decades to aid research efforts, including studies that have required psychological data collection and analysis. Few have focused on universities and even fewer on joy. Therefore, the goals of this thesis were to (1) develop a multi-faceted, community-based prototype Web mapping application that any university community member can utilize, (2) collect, visualize, and analyze current mental health data and data on where and why joy occurs on a university campus, (3) gather participant feedback for application revisions, and (4) discuss preliminary results and recommendations related to the implications the application has to the university community. The *Happy Traveler* application was built using Esri ArcGIS Online (AGOL) to create an interactive story map that collects and displays individuals'

moments of joy on and around the University of Southern California's (USC) University Park Campus (UPC). The university community can use this application to foster connections, strategically build a more enjoyable campus, and exhibit the best and most loved places in the area.

1.1. Motivation

The year 2020, fraught with a global pandemic, climate crises, and social upheavals, showed the world the devastating consequences of widespread trauma, loneliness, and exhausted mental health. University and college environments are supposed to be safe spaces for developing resilient individuals, strengthening society, and advancing knowledge, but without connection to their community, individuals may suffer emotionally. Long before those events occurred, universities observed increasing numbers of students who sought psychological counsel, had severe psychological issues or were already on psychiatric medication (Gallagher 2014). These mental health issues on and off campuses often disrupt and inhibit, individual and community growth by negatively affecting relationships, academic performance, retention, and graduation rates (Kitzrow 2003). Even when faced with these realities, many campuses still struggle to disseminate knowledge and provide adequate resources for community mental health and well-being (CMHWB).

Universities can begin fostering healthy CMHWB by understanding why and where joy occurs on campus. By studying community joy through strategic action, universities can potentially improve quality of life and CMHWB by improving spaces that already create joy and creating new ones (Fowler and Christakis 2008; Johnson 2020. This will not only help the local community but add to the societal discourse and the understudied field surrounding joy (Watkins et al. 2018). Research on joy and well-being has increased over the years, but much of society is

not aware of the knowledge that could improve quality of life. Using GIS to understand where and why joy occurs may bridge this gap and at university communities, this could potentially bolster discussions and knowledge on mental health. Therefore, the motivation for this thesis is to create a prototype Web GIS application that serves as a platform for the USC community to share their moments of joy around campus and record their current states of joy, mental health, and well-being. Developing this application may help support individuals who are struggling with their mental health, improve community resilience, and help the university's goals of supporting students through crises and their academic journeys.

1.2. Study Area

The University of Southern California is a university located in Los Angeles California. In the 2020-2021 academic year, there were approximately 19,500 undergraduates, 26,500 graduates and professionals, 4,700 faculty, and 16,600 staff. This campus was chosen because of the researcher's familiarity with the school and USC's CMHWB history. Although USC is a nationally top-ranked school, they have—like many other universities—struggled with community mental health crises. A study done by the USC Well-Being Collective (USC WBC), a university-wide effort that was created to strengthen a campus culture driven by student wellbeing (USC WBC 2021), found that only 51% of all USC students had positive mental health (USC WBC 2020). A student population with only half possessing good mental health is cause a for concern. Therefore, it is necessary to discern the reasons for such low scores and create solutions to improve community-wide mental health.

The geographic study area covers the University of Southern California's University Park Campus (USC UPC) and its surrounding community. Specifically, this project aimed to collect near real-time data from anywhere within a quarter-mile distance from the USC UPC Lyft Safe

Ride geofence (LSRG) seen in Figure 1. The LSRG is a boundary that represents the distance at which students, staff, and faculty can receive free rides from the ride-share company, Lyft (USC Transportation n.d.).

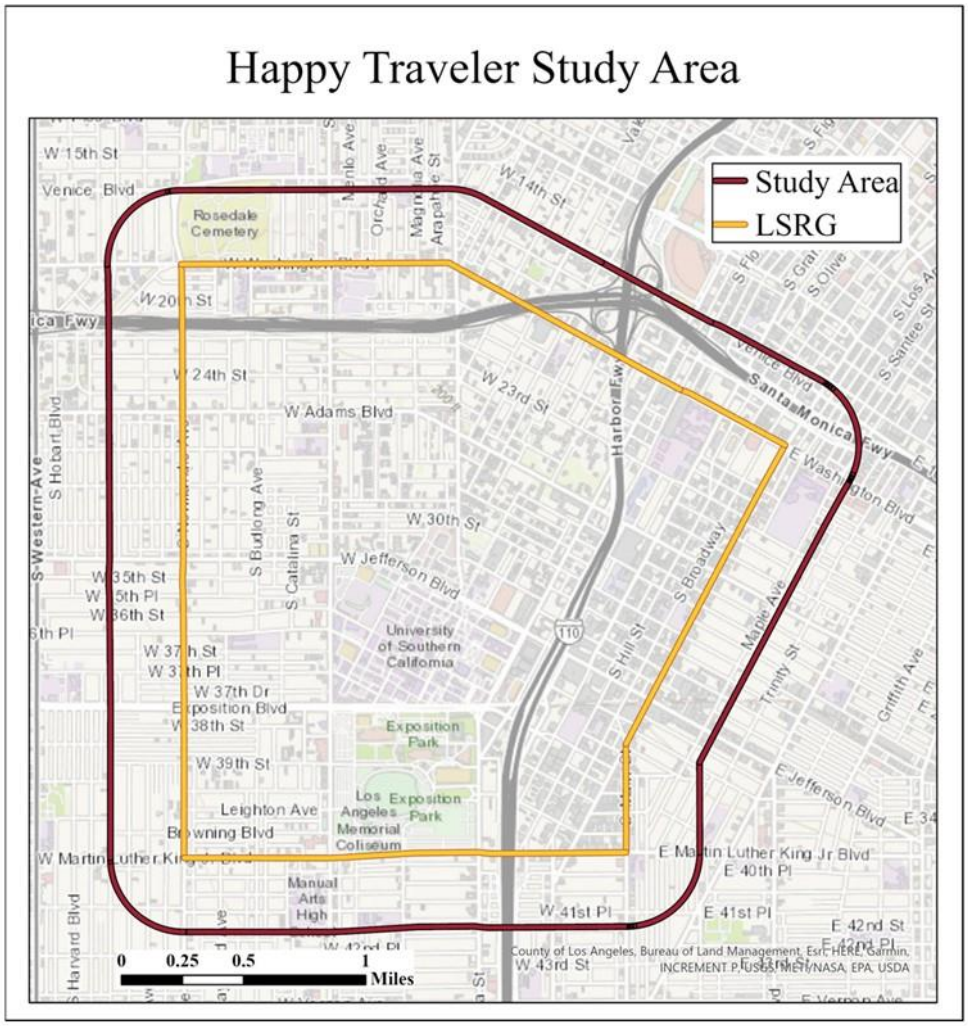


Figure 1. Map of the study area

Although this free program only operates between 7 am and 2 am, it is assumed that most individuals travel within this time frame. Additionally, the quarter-mile buffering distance was chosen as it assumes a reasonable distance for most individuals to travel using other transportation methods including, but not limited to, on foot, bicycle, or skateboard.

1.2.1. Intended Audience

The intended audience for this application is broken into three tiers of descending use. Since this application's main intended purpose is to be a community-based platform for users to share their thoughts on joy and well-being, first-tier users include UPC students, faculty, and staff. These groups spend most of their time living and working in this LSRG zone and are the individuals that will be the most engaged in this environment and affected by any events or change that occur within it. Every year, the university welcomes thousands of new members and they may not be familiar with the area because they are new to campus, or perhaps they do not deviate away from their daily routines. Regardless of their familiarity, users in this tier can use the application to share their joyful moments, discover new places, and connect with their community. The honest input received from first-tier users forms the heart of this application, but it also gives second-tier users data that they can transform to make evidence-based changes to the campus.

University decision-making and planning do not always involve the community's input, which could limit action success and effectiveness. Secondary-tier users include the university planners, architects, and mental health professionals who could use the geospatial and demographic data collected from first-tier users to observe where and why positive emotions occur within the geographic area. This application was developed in collaboration with the USC WBC, which consists of various university groups whose leadership helps make USC a better place to live, work, and learn by using a systems-wide settings approach to promoting health and wellbeing (USC WBC 2021). This collective, along with other secondary users, could utilize this data to gain a better understanding of the state of community mental health, observe where joy occurs, and enhance the campus. Third-tier users are anyone in the public who is interested in

replicating the application, researching joy, or enjoying the application since it will be freely available to view online.

1.2.2. Application Development

This project uses desktop and Web GIS platforms to develop an easy-to-use and enjoyable application that crowdsources, displays, and analyzes perceptions of joy and CMHWB. The *Happy Traveler* application was primarily built using ArcGIS Online (AGOL), a cloud-based software-as-a-service (SaaS) that hosts a myriad of GIS maps and applications. *Happy Traveler* is a story map that contains an information sheet, app tutorial, study background, CMHWB survey, response map dashboard, and feedback survey. The study area map was created in ArcGIS Pro and includes a boundary that represents a quarter-mile buffer outside the free Lyft ride zone discussed further in Chapter 3. This map is used in the survey to guide participants to choose a location within the study boundary and in the dashboard to display the study area and survey responses. Additionally, an interactive USC mental health resources map was developed using the ArcGIS API (Application Programming Interface) for JavaScript.

The four AGOL applications used in *Happy Traveler* are the Esri ArcGIS classic story maps Map Series, StoryMaps, Survey123, and Web AppBuilder. The main interface that users interact with is a Map Series story map, a tabbed application that can hold Web pages, maps, pictures, or videos. This story map was stored on a USC SSI server via FileZilla. Within the map series, there are several embedded Web pages and maps including 1) two embedded StoryMaps, AGOL applications that allow users to tell stories by sharing maps, multimedia content, and narrative, to display the Internal Review Board (IRB) information sheet, study background, and project narrative; 2) two surveys developed using Survey123 Connect and Survey123 Web Designer, a form-centric data gathering application (Law 2017), to collect data on joy, CMHWB,

and participant feedback; 3) a dashboard, created with Web AppBuilder, a what-you-see-is-what-you-get (WYSIWYG) application that allows you to build 2D or 3D map-based web apps without writing code (Esri 2020c), that display charts and statistics related to the collected data; and 4) and USC mental health resources map developed with the ArcGIS API for JavaScript. JavaScript is a programming language that allows developers to create functional and dynamic webpage content. The ArcGIS API includes specialized libraries, toolkits, and frameworks for developing web applications with GIS capabilities.

1.3. Document Structure

The goal of this project was to develop a Web GIS application that collects data on moments and perceptions of joy and well-being around the USC UPC campus. Chapter 1 has provided a general overview of the study including descriptions of the motivation, study area, and general methodology. Chapter 2 reviews literature related to joy, well-being on university campuses, GIS applications that collect data on emotions, and Web GIS. Chapter 3 describes the methods that were essential for producing a valuable and impactful community-based Web GIS application. Chapters 4 discusses the final application, preliminary test results, and participant feedback. Finally, Chapter 5 addresses the conclusions, limitations, and plans for future action.

Chapter 2 Background Literature

Researchers have studied mental health and well-being extensively over the years, and GIS has become a tool to collect, analyze, and deepen our understanding of human emotions. However, there have been few studies that have explored how researchers can use GIS to create functional and beneficial applications for supporting university campus communities. This chapter provides a review of how researchers have defined and operationalized joy in studies of well-being and emotion. Studies on environmental effects on emotion are included to provide a theoretical foundation as to the application functionality. Furthermore, focusing on crowdsourcing methods, this section looks at how past research has used crowdsourcing and volunteered geographic information (VGI) to map emotions.

2.1. Joy and Well-being

Joy and well-being are topics gaining attention in both academic research and popular media. Well-being has been well documented in the literature, but joy remains a relatively underrepresented topic, and its definitions remain disparate and fluctuating depending on the application or environment in which it exists. Previous methods used to measure joy have ranged in content and complexity. Therefore, it is necessary to find and use definitions and approaches that are conducive to the *Happy Traveler* study's development goals.

2.1.1. Defining joy

Past research has described joy as a positive emotion, a mood, a character, a disposition, a spiritual sense, or a state (APA n.d.; Johnson 2019). Joy has also been attributed to stereotypically negative outcomes, called schadenfreude, or joy from the detriment of others. Out

of the many definitions that exist, the largest scientific psychological organization in the United States, the American Psychological Association (APA), defines joy as:

> A feeling of extreme gladness, delight, or exultation of the spirit arising from a sense of well-being or satisfaction. The feeling of joy may take two forms: passive and active. Passive joy involves tranquility and a feeling of contentment with things as they are. Active joy involves a desire to share one's feelings with others. It is associated with more engagement of the environment than is passive joy. The distinction between passive and active joy may be related to the intensity of the emotion, with active joy (APA n.d.).

This definition describes both active and passive joy, but the active form specifically informs the structure and use of the *Happy Traveler* application because users are prompted to record their interactions with their environment and how it affects their emotional state. In this definition, joy is not only a feeling, but a drive to connect and engage with others and the environment.

Another semantic obstacle when defining joy is caused by its conflation with other positive emotions such as happiness, elation, excitement, and gladness. The differences between these terms remain fuzzy, but De Rivera et al. (1989) attempted to study the distinctions between elation, gladness, and joy by asking 161 students to recall their experiences with one of the three emotions. Additionally, they asked participants to describe the three emotions as they relate to a situation, bodily transformation, behavioral propensity, and function. The authors theorized that joy occurs when people feel a strong connection to life, others, and reality, in contrast to elation and gladness. However, the study struggled, in their methods and discussion, to clearly describe the delineations between words and did not come to a clear conclusion. Each of these terms may

emerge in people slightly differently and are likely due to cultural differences. However, a distinct interpretation with their conclusions and the APA definition is that joy is usually shared with others. Overall, the definitions of joy are complex and fragmented, but there are adequate commonalities, like it being a "distinct positive emotion" (Watkins et al. 2017) and its presence as an emotion that is shared, for it to be operationalized effectively.

2.1.2. Operationalizing joy

The complexity in defining joy also means that it is difficult to measure and operationalize. Researchers theorize that joy is formed both due to internal factors like genetics and hormones, and external factors including income, physical environment, social network, and fitness level (Dfarhub, Malmir, and Khanahmadi 2014). Therefore, there is potential to assess joy from several different vantage points. Watkins et al. (2017) constructed measures of state and trait joy to analyze their connection to subjective well-being. State joy refers to "the frequency of the emotional experience of joy" and trait joy refers to an individual's disposition (Watkins et al. 2017). After testing their methods on over a hundred participants, the researchers found that joy can be measured reliably by self-reporting methods and that joy is likely a significant causal factor in an individual's well-being. These findings influence this thesis such that it is crucial to understand community state joy to give individuals the best possible opportunities to grow and flourish within the university environment.

Self-reported methods like questionnaires and surveys are the most widely used tools for measuring and collecting data on emotion. Watson, Clark, and Tellegen (1988) developed the Positive and Negative Affect Schedule (PANAS), a 10-item questionnaire that could measure emotional states. This test was later expanded to a 60-item test (PANAS-X) that measures basic positive, negative, and other emotions. The PANAS-X has since become a common tool in

clinical and non-clinical research and has influenced the creation of newer studies. Recently, Watkins et al. (2018) developed a self-reported, unifactorial measure of joy, the State Joy Scale (SJS). This 11-item assessment's construct validity was evaluated by using well-tested measures like the PANAS-X. The SJS uses a 7-point Likert-type scale that is most useful for researchers studying personality and well-being, rather than a momentary experience of joy.

Today, there are various other emotional tests like the Penn Authentic Happiness Survey and Test, the Yale Happiness Test, and the True Happiness Scale (Sugay 2020), but the *Happy Traveler* Project uses the SJS and the Flourishing Scale (FS), an 8-item measure of self-reported success (Diener et al. 2010). SJS is used because it is one of few measures that measure joy specifically. FS is included because the USC WBC's Student Well-being Index Survey (SWIS), an annual assessment that tracks the USC student population's health, uses it to measure high positive well-being. By incorporating work done by the USC community, it ensures that the goals of this study and those of the university are aligned. In *Happy Traveler,* an average of at least six, 66 or more out of 77 for high joy (SJS) and 48 out of 56 for high positive mental health (FS).

The WBC's Positive Mental Health Data Update (2020) reported that 51 percent of all USC students had positive mental health. Higher mental health scores were positively correlated with age, degree level, and cis heterosexual individuals. For undergraduates, Latinx/Hispanic cis-heterosexual men, Arab/Middle Eastern cis heterosexual women, and white cis-heterosexual women were reported to have the highest population with high mental health scores. These statistics were used to compare the beta test results in Chapter 4.

Although most research suggests that joy is a discrete positive emotion that can be reliably measured by self-reporting (Watkins et al. 2017), there are several limitations to post hoc

self-reporting (PHSR) methodologies that must be considered. Johnson (2019) lists four main barriers to accurate joy reporting. First, memory is highly plastic and prone to error, therefore people do not remember the past accurately. Therefore, reporting perceptions and feelings of joy after the fact may not result in the most accurate responses. Second, mood-congruent recall may affect an individual's responses because their current mood might alter how they remember events. If an individual is in a negative emotional state while reporting their perceptions of joy, they might report a lower score than if they were in a positive state. Third, subsequent judgments about the experience may affect or have affected how people remember and recall. For example, if an individual felt joyful all day, but at night they received bad news, they might view the entire day as negative if they recalled it in the future. Fourth, social desirability may change participants' accounts based on what they think other people might respond, or how others think about their response.

Several other self-reporting techniques for collecting data on well-being exist that avoid some of PHSR's pitfalls including the ecological momentary assessment (EMA) and the day reconstruction method (DRM) (Stone and Mackie 2013). Stone and Mackie (2013) describe EMA as a method that asks participants to record their immediate feelings or experiences at specific times during the day. The authors note that this method is advantageous because the researchers do not have to worry about the participants forgetting or misremembering their emotions. However, EMA is difficult because requires participants to respond when prompted, usually at random intervals throughout the day (Johnson 2019). This method can be intrusive and inconvenient because it makes the person stop what they are doing, and it may induce negative affect and influence their answers. Furthermore, this method may be challenging for people with

certain disabilities or who do not have access or knowledge of the specific technology (Stone and Mackie 2013).

The DRM is a diary-like approach that prompts users to recall specific times during the day and to rate those activities on a numeric scale (Stone and Mackie 2013). This method is less intrusive and scalable than ERM and it does not account for joy felt at other times or places and it is subject to a biased memory. However, Sone and Mackie (2013) state that DRM does reduce the bias found in PHSR because it is more structured and recent experiences are easier to recall. Overall, between these methods, self-reporting is the most effective for this study and will be employed by using a survey within the application.

2.2. Environmental Effects on Emotion and Well-Being

Just as humans terraform and modify their world, environments influence and mold human behavior and emotions. At universities, many individuals, including new students, are subject to unprecedented levels of emotions like fear, apprehension, stress, and excitement due to their exposure to the environment. Therefore, universities must design the physical and cultural aspects of their campus in a way that promotes positivity, inclusion, and community, and help give the university a more holistic strategy to improving campus-wide mental health.

2.2.1. Environment and positive emotions

Environments can have a wide range of impacts on human emotions from fear to sadness to happiness (Hipp et al. 2015; Jeantete 2019). By specifically investigating positive responses to environments, researchers can use these data to illuminate why it occurs and support the creation of more positive spaces. One heavily studied branch of this research is related to the impact of green spaces on well-being. For example, Barton and Rogerson (2017) reviewed studies on greenspace and mental health and found that green spaces are correlated to reduced disease

prevalence and mental health issues like anxiety and depression. They report that outcomes are not always directly caused by the greenspaces, but by what can occur in greenspaces like social gatherings and physical activity. Therefore, it important to recognize that there are multiple variables to account for when analyzing how environments affect well-being.

Universities campuses are environments that crucial to study because they can influence their community's mental health and well-being. Hipp et al. (2015) researched the relationship between perceived greenness and student-reported quality of life at three universities—two in the United States and one in Scotland. In their study, they use questionnaires to collect participant data and find that perceived greenness is correlated to a higher quality of life, but this is likely due to how people perceive restorative places. The results from this study show expose how physical environments affect students' lives and could be useful to universities that want to know how to most effectively spend their resources to create environments that students will enjoy and thrive in. Furthermore, this can foster the mentality that the campus environment can be a mental health resource, rather than only relying on traditional mental health resources (Hipp et al. 2015).

2.3. Crowdsourcing and GIS

In various disciplines, the progression and acceptance of volunteered geographic information (VGI) and public participatory GIS (PPGIS) has greatly benefited research, knowledge dissemination, and spatial understanding at local and global scales. Researchers using crowdsourcing methodologies have increasingly looked to Web GIS to support their endeavors because of its high usability and accessibility. Within the GIS domain, the definition of VGI is distinct because it focuses more on the data and how it is collected, whereas PPGIS is directed at the processes and outcomes of citizen involvement tied to decision making and community enhancement (Goodchild 2007a; Tulloch 2008; Verplanke 2016).

2.3.1. Defining crowdsourcing methods

As crowdsourcing methods progressed over time, many different scholars have commented on the distinctions between the different terms, uses, and limitations. Goodchild (2007a) assesses the validity of VGI data as it gains traction in academic research. He finds that VGI has great potential, but it has many limitations regarding quality, error detection, and trustworthiness. Goodchild (2007b) again considers citizens as sensors and VGI but discusses it in the context of Web 2.0 and the many other types of technology that support crowdsourced geographic data. Tulloch's (2008) paper reviews two studies to differentiate VGI and PPGIS. See et al. (2016) and Verplanke et al. (2016) both complete reviews of the current states of crowdsourcing and GIS, clarify definitions, and include examples. Bubalo (2019) reviews different crowdsourcing GIS applications dedicated to collecting landscape perceptions.

Although these distinctions exist, this thesis uses the term "crowdsourcing" to refer to VGI. This project integrates data collected from the public into the design, development, and execution of the web mapping application by allowing anyone to add geographic information. Users can choose whether they want to utilize the data to plan, make better decisions, and improve their community. While this is a good starting point, community members are not yet part of the planning. In the future, more PPGIS methods will hopefully be implemented to create an application created by the community, for the community.

2.4. Emotion Mapping

In previous research that used crowdsourcing and participatory methods, most investigated topics related to health, tourism, navigation, or disaster management, but few focused on emotion mapping (Poplin 2015; Poplin, Shenk, and Passe 2017; Poplin, Yamu, and Rico-Gutierrez 2017). Emotion mapping is the process of adding an emotional element to

geographic locations. Griffin and Mcquoid (2012) divide emotion mapping into three categories including 1) maps of emotions, 2) using maps to collect data on emotions, and 3) users' emotions while using maps.

2.4.1. Emotion mapping methodologies

When GIS technology is not available, researchers collect geographic data on emotions using mental and drawn maps to untangle and visualize the subjective feelings that individuals expressed about certain locations (McGrath, Mullarkey, and Reavey 2019). McGrath, Mullarkey, and Reavey (2019) reported on two participatory mapping studies hand-drawn methods. The first study focused on recording the "experience, creation, and negotiation of psychological, spatial, and emotional boundaries" of adults with learning disabilities. The study used paper maps and differently colored stickers to represent locations and emotions. The second study looked at the role that space has for individuals using mental health services. The researchers asked participants to 1) draw a map, 2) draw whom they saw, what they did there, and how they felt, and 3) answer questions about their relationship between the spaces they occupied and the experiences they had.

As McGrath, Mullarkey, and Reavey (2019) demonstrate, analog mapping methods have several advantages depending on what applications researchers use them for. For example, they are cost-effective, easily accessible for people with certain disabilities, easy to draw on, modify, and they give an overview of the geographic location (Pauschert et al. 2011). Conversely, Pauschert et al. (2011) explain that digital maps are beneficial over their analog counterparts because users can access large amounts of data at once, add and view multimedia content, modify and create new data, and access and share dynamic information. Digital maps still have limitations because they rely on battery power, internet connection, and technological

knowledge. However, the advantages of digital maps outweigh the negatives in the case of building an emotion mapping application that requires input from users that are socially distanced and can update, visualize, and share data in near real-time.

2.4.2. Using Web GIS to map emotions

Since its inception in 1993, Web GIS has become a ubiquitous part of everyday life whether we recognize it or not. We use these technologies to check California fire updates through Cal Fire, navigate to the most popular plant nurseries with Google Maps, locate our kids on mobile tracking apps, and more. Fu and Sun (2011) describe Web GIS as a distributed information system that facilitates communication through web technology between at least one GIS server and one web, mobile, or desktop client. Web 2.0 and the acceptance of common standards have led to an explosion of web GIS applications that grant "interactive information sharing, interoperability, user-centered design, and collaboration on the World Wide Web" (Batty et al. 2010). Additionally, the omnipresence of mobile devices, open-source GIS platforms, satellite technology, and other GIS-related technology has made it possible for almost anyone to create, edit, analyze, and visualize spatial data (Goodchild 2007) quickly and simply.

As technology has progressed, more studies have used GIS, the World Wide Web, and mobile devices to capture emotions from people almost anywhere and in real-time. Several mobile and web-based applications and projects dedicated to mapping emotion already exist for making better decisions regarding planning and policy, innovation in navigation and location-based services, and citizen engagement. For example, Mappiness is an early emotion mapping iOS mobile application that was created to understand the relationship between happiness and location (MacKerron and Mourato 2013). The application prompts users to report the extent to which they feel "happy" on a sliding scale and records user location, information on who the

user is with, where they are, what they are doing, land cover, weather conditions, and daylight status. In their study, MacKerron and Mourato (2013) found that happiness was greatest in green and natural environments and argued that policymakers could use this data to inform decision-making processes. However, they recognized that their results were limited due to their study's sample size and characteristics.

Using independently build and managed applications, like Mappiness, are useful, but time and cost-intensive. Over the years, companies like Esri have pioneered out-of-the-box and customizable Web GIS by creating intuitive, robust platforms for quick and easily accessible web application and service development. Esri's ArcGIS Online (AGOL) is a cloud-based, Software-as-a-Service (SaaS) mapping and analysis platform that allows users to design maps, build web applications, process data, and share geographic information with people from all over the world (Esri 2020a). There are various types of AGOL applications, but this thesis used three--ArcGIS StoryMaps, Survey123, and ArcGIS Web AppBuilder--to create the final application. ArcGIS StoryMaps is a platform that facilitates users sharing their stories by creating maps, narratives, and multimedia content (Esri 2020b). Survey123 is a form-centric application that enables users to collect, share, and analyze spatial data, survey data, and other information from users (Law 2017). Web AppBuilder is a WYSIWYG application that helps users to create 2D or 3D web applications using out-of-the-box or customized widgets (Esri 2020c).

One application that utilizes the AGOL suite is a visual pollution application presented in a study by Chmielewski et al. (2018). The researchers combined ArcGIS Story Map Cascade, Geoform, 3D Viewer, and Operations Dashboard to create a Web GIS application that collects crowdsourced data on the perception of visual pollution in Lublin, Poland. In their study, they expand the functionality of the out-of-the-box applications by writing a custom Python script that

delivers near real-time quality control and statistics. The research by Chmielewski et al. (2018) demonstrates the ability of cloud-based platforms and customized scripts to create powerful crowdsourcing applications. *Happy Traveler* uses methods inspired by this study, but it expands on it by using a more recently updated version of AGOL to create an application that collects, stores, visualizes, and shares data on joy on a university campus.

2.4.3. Mapping emotions on school campuses

Few studies have targeted school and university populations to map emotions. Poplin, Yamu, and Rico-Gutierrez (2017) studied students' power places, locations "in which people recharge and feel at peace or exuberance, a place that evokes positive feelings," to better understand public spaces and place-making and help create healthier, more sustainable communities. This study used surveys to collect, analyze, and visualize data on how students perceived the places within their community, the places' physical characteristics, individuals' descriptions of these places, and the words used to describe the places. Similar to MacKerron and Mourato (2013), many of the reported places were open, green spaces, near water, clean, or calm. Some of the main emotions that individuals reported in their power places included: happy, relaxed, quiet, calm, exciting, and love. The researchers note the participants' difficulty in assigning a single point to their power place and defining the place which introduces the problems of scale and definition.

Similarly, Deitz et al. (2018) and Oikonomidoy et al. (2020) both used emotion mapping to understand how young people view and use their environments. Deitz et al. (2018) held workshops to help younger generations engage in urban planning by matching places in their city with emotional terms and colors. Oikonomidoy et al. (2020) studied how marginalized groups feel in campus spaces by having students place happy and sad stickers at different locations.

EmoMap is a project that plans to execute a mobile application that collects VGI from users on their emotions to add emotion information layers and smarter services to location-based services (Klettner, Huang, and Schmidt 2011). The researchers developed a hierarchical emotion model that will underpin their future data collection. The three levels include: 1) how pleasant individuals perceive the environment to be, 2) the dimensions of stress versus relaxation and excitement versus boredom, and 3) the environmental aspects like traffic noise, smell, people, safety, attractiveness, and diversity.

The previous studies used different methods to collect, quantify, and map emotions. Each one informed this thesis project's methods differently. This thesis combines different aspects of these methodologies to produce a cloud-based Web GIS application using AGOL that collects and visualizes perceptions of joy at the university campus level.

Chapter 3 Methodology

This study developed a web mapping application that facilitates community members to anonymously share their experiences of joy and mental health. This data is added to an interactive dashboard that displays participant responses and related statistics on a map in near real-time. This chapter describes the data and processes used to craft a crowdsourcing instrument that is intended to be valuable, straightforward, and enjoyable. The specific subsections cover the application requirements, data, design, and launch.

3.1. Application Requirements

To create a community-based mental health GIS application that is effective and functional for a diverse set of users, careful considerations were made regarding the application platform, application design, survey design, and user interface.

3.1.1. Application goals

The main goal of this thesis project was to develop a GIS application that can collect, visualize, and analyze the spatial, temporal, and explanatory variables that represent the awareness and perceptions of joy and well-being at the USC UPC. *Happy Traveler* had to be optimized so that university stewards and community members could utilize it to report and reflect on the state of community mental health, but simple enough for anyone to use. When designing GIS applications, the data collection and analytical aspects are typically the priority. However, for first-tier users, these are less important because their contribution to the app is centered on their personal accounts and storytelling. Without community support and interaction, the application would be useless. Thus, *Happy Traveler* needed to be an application that is attractive, engaging, and worthy of habitual visitation. The app also required streamlined data

collection processes and near-real-time updating so that participants could see easily and immediately see their inputs among other respondents in the map and dashboard. Regardless of user classification, today's technology consumers expect quick loading times, attractive design, easy-to-use interfaces, and accessible, high-quality content.

Secondary users benefit from the aforementioned application properties, but they also require a higher level of consideration because if the app were to be integrated as a permanent university mental health resource, secondary users would be the principal data managers, analysts, and administrators. Therefore, they need an app that is cost-effective, easy to employ, edit, manage, and understand. Third-tier users are the class of least importance for this study because they are the least likely to use *Happy Traveler* and will likely observe the application, rather than use it. They do, however, benefit from all of the considerations made for the other two classes because they can either view the app for pleasure or try to replicate the process for their community. In summary, user-oriented development choices focused on 1) primarily front-end design, content, and functionality choices for first-tier users, 2) back-end design, analysis, data storage, and management for second-tier users, and 3) all previously mentioned choices for third-tier users. The goals and requirements discussed here reflect the development choices described in the rest of this chapter.

3.1.2. User Requirements and Sample Population

Happy Traveler centers on the joyful experiences and survey responses disclosed by community members. Specifically, first-tier users include individuals who spend the most time within the study area like university students, staff, and faculty. These are the users whose responses will form the heart of the application and may benefit most from using *Happy Traveler* more frequently. This is because the more stories and data that are added, the more likely other

community members will visit *Happy Traveler* to view the dashboard, add data, and analyze it for trends. Once *Happy Traveler* is released publicly, the goal is to engage all USC community members so that the map dashboard is representative of the university's diverse population. However, since this study was only used to test the application's functionality and to gauge future interest, participants were selected based on convenience using an email list-serve provided by the USC WBC and personal contacts. 1,000 USC students and ten personal contacts were sent an IRB-approved email containing information on the study and a link to *Happy Traveler*.

To take part in the beta test, prospective participants had to be over the age of 18, have access to an internet connection, a device with a web browser, and a basic understanding of how websites work. Although there were explicit instructions on how to use the app in an app tutorial located on the application's first page, it could be difficult to understand and navigate if the participant has never used a website before. Since the intended targets are university community members, it is assumed they have used basic web and mobile apps. Participants were not obligated to complete the survey and had the choice to leave items blank if they did not feel comfortable answering. No identifying information was collected from participants in the *Happy Traveler* survey and the data was stored on a secure database within the AGOL cloud which is all Hypertext Transfer Protocol Secured (HTTPS). This means that data entered into the app is encrypted and transferred over a secure connection so that attackers cannot steal information like passwords or Internet Protocol (IP) addresses to locate or identify participants. The feedback survey was stored identically, but email data was collected so that the researcher could send out follow-up emails for a second beta test.

3.2. Data Description

Quality data and databases underpin any successful application, including *Happy Traveler,* but this application did not require many datasets to initially develop since the crowdsourced data would eventually come from survey inputs. The datasets that were used included a Los Angeles Roads dataset to create a study area boundary feature layer to embed in the *Happy Traveler* survey and dashboard.

Table 1. Data table

Dataset	Description	Use	Source	Date
Roads (shapefile)	All roads for Los Angeles County	Used to create the five-minute boundary	U.S. Census Bureau	2019
LSRG Boundary (static map)	The UPC Lyft Safe Ride program geofence that operates between 7 AM to 2 AM daily	Replicated to create the five-minute LSRG walking boundary	USC Transportation	2019
Five-Minute Boundary (polygon feature class)	A five-minute walk time buffer of the LSRG boundary	Embedded in the *Happy Traveler* survey and the dashboard. Participants choose a joy location within this boundary	Developed for the project in ArcGIS Pro	2020
Survey Attribute Data (point feature class)	Respondent inputs from the *Happy Traveler* demographic, joy, and well-being items	Used to display and analyze perceptions of joy and well-being	Survey responses	2021
Mental Health Resources (point feature class)	Information on various mental health resources on the USC UPC	Used to display a map of mental health resources	USC Student Health	2021

3.2.1. Roads

This dataset is a current and authoritative source of road line data from the TIGER/Line 2019 Shapefiles dataset authored by the United States Census Bureau. This dataset was projected to the NAD 83 2011 State Plane California Zone Five (US Feet) coordinate system so that the map displayed accurate distances when creating the LSRG boundary buffer.

3.2.2. LSRG Boundary

The LSRG boundary represents the distance an individual can reach using the free Lyft rides that are available for students, faculty, and staff (USC 2019). This polygon feature class was created in ArcGIS Pro, an Esri desktop GIS application, by replicating the map from the USC Transportation (USCT) website at the largest scale possible. In ArcGIS Pro, a new file geodatabase feature dataset, Roads, was created to house the data. The Roads dataset was projected from the North American Datum 1983 (NAD 83) to the NAD 83 2011 State Plane California Zone Five (US Feet) coordinate system so that the map had accurate distances when forming the buffer. The Select by Attributes tool was used to select the required roads by name and these shapefiles were copied using the Copy Features tool into a new file geodatabase feature class. These features were manually edited by deleting vertexes to match the USCT map. The resulting feature class matched the static USCT geofence map.

3.2.3. Five-Minute Boundary

The five-minute boundary is representative of how far an individual might travel outside the UPC. Five minutes was chosen because it assumes a safe and reasonable distance to travel with or without using the free Lyft rides. To create the boundary, the Buffer tool was used to create a five-minute walking distance buffer with rounded edges around the LSRG boundary. Unnecessary line data were deleted, and the boundary was symbolized as a red line. The OpenStreetMap basemap was selected because it clearly and simply displayed buildings and open areas for users to easily locate and recognize locations. Finally, the map was projected into the Web Mercator coordinate system, since AGOL requires this projection for web maps, and published to the AGOL cloud.

3.2.4. Survey Data

The *Happy Traveler* survey collected demographic, spatiotemporal, and explanatory variable data from participants. They could choose to leave questions blank if they did not want to answer, but they were encouraged to answer all questions. The two items prompted users to select a point within the five-minute boundary that represents a moment of joy they have experienced and the date and time they experienced that moment. The demographic information collected from users includes age, first-generation, gender, sexual orientation, race/ethnicity, education level, and affiliation to USC. The demographic items were modeled off of the SWIS, but the affiliation item was modified to include UPC visitors. The SWIS included several more demographic items, but many were redundant and would have made the survey too long. Therefore, only those listed previously were included. The last 19, seven-point Likert scale survey items include eight questions from the FS and eleven items from the SJS. When a participant completes the survey, the scores for the FS and SJS are combined to create the well-being and joy score attributes.

3.2.5. Mental Health Resources

A list of mental health resources and their accompanying hours, address, website, phone number, description, and email were acquired through the USC Student Health website. These resources were added to a web map in AGOL and used on the mental health resources page.

3.3. Application Platform and Design

One of *Happy Traveler*'s main goals was to accommodate users that have never used a web map before to those that have had years of experience. Hence, this app had to be accessible, engaging, effective, scalable, cost-effective, and easily managed. The rest of this section dives

into exactly how those goals were achieved by discussing the application requirements, data description, and application interface and design.

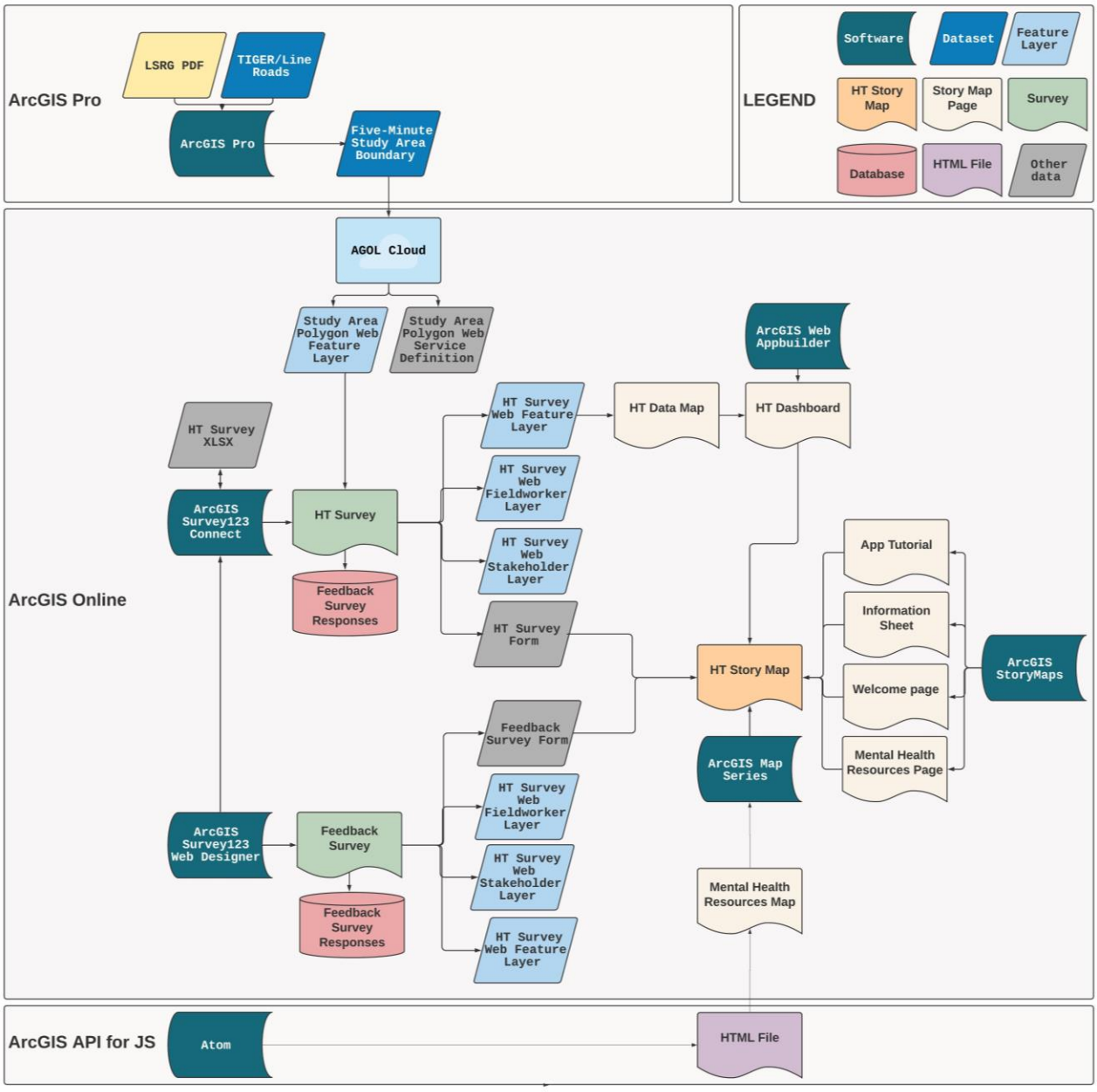


Figure 2. Workflow diagram

3.3.1. ArcGIS Pro

The five-minute boundary described in Section 3.2.3 was created and published from ArcGIS Pro as a feature layer to be used in the *Happy Traveler* survey and dashboard. Once the

item is published into the AGOL cloud, it is permanently stored and available to use in maps and applications.

3.3.2. ArcGIS API for JavaScript

The ArcGIS API for JavaScript contains libraries that allow developers to write scripts for web applications with GIS capabilities. This method of app creation is used when developers need to create apps with specific functionality or design that they cannot get from traditional WYSIWYG pre-built apps. For the *Happy Traveler* application, the API was used to develop a browser-side script that serves an app—displaying USC mental health resources with customized pop-ups—to the user within the *Happy Traveler* story map. The API's hosted version was accessed using the asynchronous module definition (AMD) via the ArcGIS content delivery network (CDN) which required adding script and link tags into the HTML document (Figure 3). The AMD defines the API and its modules, and the CDN is comprised of geographically distributed web servers. This method was used because together, it provides simple and efficient access since the developer does not need to download or re-install the API.

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="utf-8" />
        <title>Mental Health Resources Map</title>
    <meta name="viewport" content="initial-scale=1, maximum-scale=1,user-scalable=no" />
    <link rel="stylesheet" href="https://js.arcgis.com/4.18/esri/themes/light/main.css" />

    <style>
      html,
      body,
      #viewDiv {
        padding: 0;
        margin: 0;
        height: 100%;
        width: 100%;
      }
    </style>
    <script src="https://js.arcgis.com/4.18/"></script>
```

Figure 3. Esri API for JavaScript AMD script and link tags

The USC mental health resource map application required several modules, each of which performed a different function. These modules are loaded by adding their classes into the required function at the beginning of the script. After the modules are loaded, objects can be created to serve a specific functionality. In this application, the following classes were added to the script: Map, MapView, Expand, BasemapGallery, LayerList, Locate, FeatureLayer, PopupTemplate, and watchUtils.

The Map and MapView classes (Figure 4) are used to store, display, and interact with a map and its layers. The Map class defines how the layers are stored, managed, and overlayed, while the MapView class defines how it is displayed and how it functions. This application has a map object that loads a gray basemap so that the map is not overwhelming to the viewer. The map view defines the zoom level, center coordinates, and other properties including pop-ups. The PopupTemplate class (Figure 5) defines the content within the pop-up when a user interacts with a layer. The pop-up “fields” and “text” content types are used to display specific attributes from the layer and information on each of the resources.

```
//Create map
const map = new Map({
  basemap: "gray",
});

//Create map view
const view = new MapView({
  map: map,
  container: "viewDiv",
  zoom: 15,
  center: [-118.2856, 34.021],
  popup: {
    defaultPopupTemplateEnabled: false,
    dockEnabled: true,
    dockOptions: {
      buttonEnabled: false,
      breakpoint: false
    }
  }
});
```

Figure 4. Map and MapView objects

```
var template = {
  // autocasts as new PopupTemplate()
  title: "{Name}",
  content: [
    {
      type: "text", // Text content
      text: "{Des}"
    },
    {
      type: "fields", //attribute content
      fieldInfos: [
        {
          fieldName: "Hours",
          label: "Hours"
        },
        {
          fieldName: "Address",
          label: "Address",
```

Figure 5. Pop-up template content

The pop-up requires a layer to pull data from, therefore, the FeatureLayer class (Figure 6) specifies which feature service to use. The uniform resource locator (URL) of the hosted AGOL layers' representational state transfer (REST) endpoint is added as a property to load the layer. In this case, the REST URL for the mental health resources feature service was used. After the main

content was added to the script, the Basemap Gallery (Figure 7), Layer List (Figure 8), and Locate widgets (Figure 8) were added to provide additional functionality. The layer list widget allows the user to turn the layer on and off, the basemap gallery allows the user to change basemaps, and the locate widget allows the user to zoom to their location. Each of these widgets were nested in an Expand widget which turns each widget into a collapsible button. In addition to the API script, a simple message (Figure 9) was added to the HTML document body to inform users to click on the points to view the pop-ups. Once the code was complete, the HTML document was stored on a server via FileZilla and embedded into the story map. Developing an application as simple as this requires meticulousness, time, and base knowledge of HTML and JavaScript. Therefore, the remainder of *Happy Traveler* was developed using a combination of customizable applications on ArcGIS Online.

```
// references layer for pop-up
var featureLayer = new FeatureLayer({
  url: "https://services1.arcgis.com/ZIL9uO234
  popupTemplate: template
});
map.add(featureLayer);
```

Figure 6. Feature layer reference for pop-up

```
//add basemap widget
var basemapGallery = new BasemapGallery({
  view: view,
  container: document.createElement("div")
});

// Expand variable to collapse basemap widget

var bgExpand = new Expand({
  view: view,
  content: basemapGallery
});

basemapGallery.watch("activeBasemap", function() {
  var mobileSize =
    view.heightBreakpoint === "xsmall" ||
    view.widthBreakpoint === "xsmall";

  if (mobileSize) {
    bgExpand.collapse();
  }
});

view.ui.add(bgExpand, "top-left");
```

Figure 7. Expanded basemap widget

```
// add LayerList plus legend widget
const layerList = new LayerList({
   view: view,
   listItemCreatedFunction: function(event) {
     const item = event.item;
     if (item.layer.type != "group") {
       item.panel = {
         content: "legend",
         open: true
       };
     }
   }
 });

//expand layer list
layerListExpand = new Expand({
  expandIconClass: "esri-icon-layer-list",
  view: view,
  content: layerList
});
view.ui.add(layerListExpand, "top-left");

var locateBtn = new Locate({
  view: view
});

// Locate widget
view.ui.add(locateBtn, {
  position: "top-left"
});
```

Figure 8. Expanded layer list and locate widgets

```
<body>
      <div id="viewDiv"></div>
  <div id="titleDiv" class="esri-widget">
        <div id="titleText">Click on a red point to read more about the resource </div>

  </div>
</body>
```

Figure 9. Informational text box

3.3.3. ArcGIS Online

The ArcGIS Online (AGOL) platform was chosen because it includes several different types of applications that have varied capabilities, are accessible, widely used, and cost-effective. *Happy Traveler* was developed with user access in mind which meant that users would not have to download additional software or native applications. This made choosing the AGOL cloud-based GIS mapping software platform an easy choice because the application could be accessed, stored, managed, and recreated with a web browser and an internet connection on either a mobile device or computer. Additionally, many university entities, including the USC Spatial Sciences Institute (USC SSI), maintain strong relationships with Esri and use the platform as a research and learning tool.

The AGOL SaaS can be accessed using a free public account or as a paid subscription. The free account only allows users to access, share, create, store, and manage basic geospatial content. ArcGIS Map Series and StoryMaps are both available for free with a basic account. With the paid subscription, users have access to a plethora of applications, analytical capabilities, and management tools. These applications can be used out-of-the-box or customized with code to suit the users' more specific needs. *Happy Traveler* used an AGOL organizational account tied to USC SSI which allowed access to applications not available in the free version including Survey123 and Web AppBuilder.

3.3.4. Map Series

Happy Traveler is hosted within an ArcGIS Map Series, a collection of pages in a single layout that can display maps, web pages, photos, or videos (ArcGISa 2020). This Map Series named the "*Happy Traveler* Story Map", was designed to have seven pages, or tabs (Figure 10), with different apps or content embedded into each. Each tab within the story map includes a customizable side panel (Figure 11) where the developer can add text, links, and graphics besides the main content. In these side panels, developers can also program story actions that can make the content more interactive by changing map locations, displaying pop-ups, switching content, and more. To make this app easier for participants to navigate, story actions and customized Hyper Text Markup Language (HTML) code was added to create buttons to go to different pages within the story map (Figure 12).

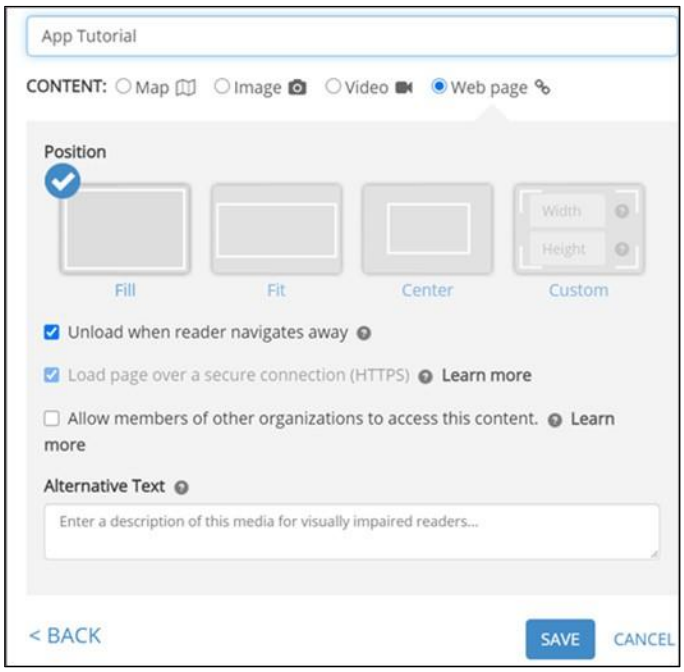


Figure 10. Map Series content edit tab

Figure 11. Sidebar editor view

```
<p>After you read this page, press this button or click the Information Sheet tab.
If you&#39;re on mobile, click the menu button on the top left. </p>

<p><span><a class="btn-new" data-storymaps="MJ-ACTION-1614025891699"
data-storymaps-type="navigate">Click here to continue</a></span></p>

<p><span>If you&#39;ve already been here and want to go straight to the map dashboard
<a class="btn-blue" data-storymaps="MJ-ACTION-1615502162610"
data-storymaps-type="navigate">click here</a></span></p>
<style type="text/css">.btn-orange {
    display: inline-block;
    font-weight: normal !important;
    background-color: #FFFFFF;
    color: #FFFFFF !important;
    border-bottom: 2px solid #995541 !important;
    width: 50%;
    border-radius: 2px;
    padding: 1px 2px;
    margin: 2px;
}
.btn-orange:hover {
    background-color: #995541;
    border-bottom: 2px solid #995541 !important;
    color: #FFFFFF !important;
  -webkit-transition: all .5s ease;
  -moz-transition: all .5s ease;
  -o-transition: all .5s ease;
  transition: all .5s ease;
```

Figure 12. Sidebar source code

In addition to these simple customizations, the entire application was customized using the open-source code to make the application unique to the project and so that it could be hosted on a different server. The open-source files for the classic story map configurations are available for free on GitHub and there are two versions: source and compiled. The source code is what developers use to customize the application's functionality (Evans 2017). The compiled code is an optimized version of the source code that is used to customize the design and to deploy the application. For this application, the compiled code was used to add a customized banner using

HTML and Cascading Style Sheets (CSS). The header banner, color, and font styles for the mobile and desktop versions of the application were customized by editing the style section in the compiled code (Figure 13).

```
<style>

    #headerDesktop {
        background-color:#185689;
        background-image: url("images/header.svg");
        background-repeat: no-repeat;
        background-position: center;
        margin-left: auto;
        margin-right: auto;
        width: 100%
            }

    #headerMobile {
        background-color:#185689;
        background-image: url("images/header_mobile.svg");
        background-repeat: no-repeat;
        background-position: center;
        margin-left: auto;
        margin-right: auto;
        width: 100%
            }

    #headerMobile .title {
        font-family: Garamond, serif;
        font-weight: bold;
        font-size: 4vw;
        text-align: center;
        color: #9d2237;
        margin: 0;
        overflow: hidden;
        padding-left: 20px;
        margin-top: 0px;
        text-shadow: 0 0 3px white, 0 0 5px #16697a;

            }

    #headerDesktop .title {
        font-family: Garamond, serif;
        font-weight: bold;
        color: #9d2237;
        margin: 0;
        overflow: hidden;
        padding-left: 20px;
        margin-top: 0px;
        text-shadow: 0 0 3px white, 0 0 5px #16697a;
            }
    #headerDesktop .subtitle {
        padding-left: 20px;
        overflow: hidden;
        text-overflow: ellipsis;
        -o-text-overflow:ellipsis;
        text-shadow: black 0.1em 0.1em 0.2em;
        color: white;
            }

    #headerDesktop .linkContainer a {
        font-weight: 400;
        font-family: Garamond, serif;
        color: inherit!important;
            }

</style>
```

Figure 13. Customized minified code style edits for mobile and desktop views

To deploy the customized compiled code, the owner needs to input the application's unique identification number (ID) into the parameter, "appid", which tells the browser to load a specific application (Figure 14). Once the code for the *Happy Traveler* Story Map was ready for deployment, the files were stored on the USC SSI server via FileZilla. This meant that the application was hosted on the USC SSI server, but the content was securely hosted within the AGOL Cloud.

```
<script type="text/javascript">
    //--------------------------------------------------------------------------------------------
    //     Application configuration (ignored on ArcGIS Online, Portal and during development)
    //--------------------------------------------------------------------------------------------
    var configOptions = {
        // Enter an application ID created through the Map Series builder
        appid: "b35801cb374b43fc845e285a6fc643e0",
        // Optionally to secure Series's access, use an OAuth application ID (example: 6gyOg377fLUhUk6f)
        // User will need to sign-in to access the viewer even if your application is public
        oAuthAppId: "",
```

Figure 14. AppID specification for the minified Map Series code

3.3.5. StoryMaps

ArcGIS StoryMaps is an application that enables storytellers to develop a narrative with the support of maps and other multimedia content (Esri 2020b). StoryMaps was chosen instead of the Classic Story Map templates because the functionality in StoryMaps is equal to the combined functionalities of the classic versions. Additionally, Esri has urged users to transition to this newer platform by constantly updating the application to add new functionality. For *Happy Traveler*, StoryMaps was used to create the app tutorial, information sheet, welcome page, and mental health resources page. Although each story map was created separately, the StoryMaps application has a theme builder (Figure 15) which allows users to create customized themes and apply them to any story they create. For *Happy Traveler*, a single theme was created and used across all applications (Figure 16).

Figure 15. How a self-hosted Story Map works. Source: Evan 2017

While each of the pages mentioned previously used StoryMaps, they all perform differently because StoryMaps has a myriad of design choices. The app tutorial used sidecar blocks which combine slides and multimedia content to create an immersive experience. As a user scrolls down, the background media and side panel text changes. The app tutorial had thirteen slides to take participants through a walkthrough demonstration of how to use *Happy Traveler*. The information sheet only used basic text blocks to provide information on study purpose, confidentiality, and participant involvement. This simple design choice was made because this page is only important to the study and not the application content or functionality.

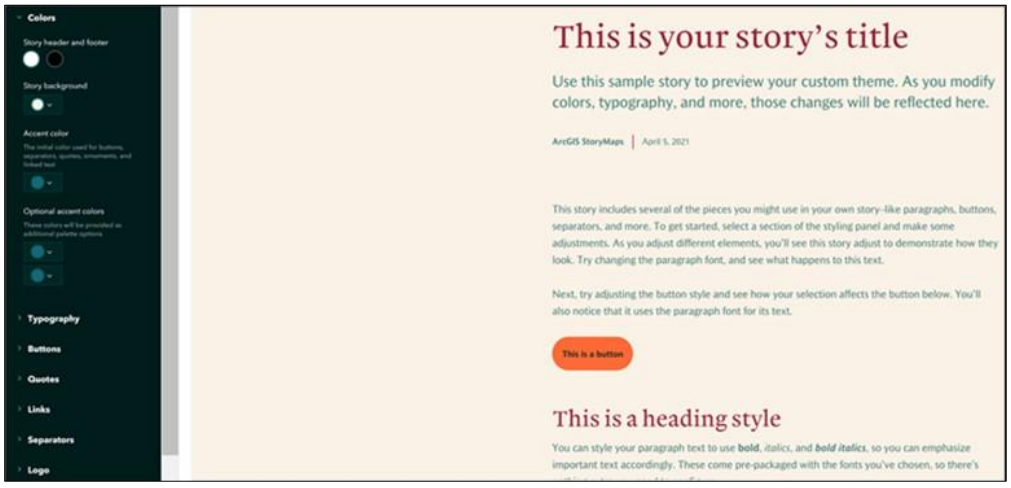


Figure 16. Theme builder

The welcome page used slideshow content blocks (Figure 17)to display information on joy, mental health, well-being, and the *Happy Traveler* project. Similar to the sidecar, the slideshow (Figure 18) uses interactive and multimedia content through slides. This page used twelve slides that users can click through from left to right. The mental health resources page uses a guided map tour and embedded web map to show mental health resources on the USC UPC campus. The guided map tour combines multimedia content with a map to take users through a list of locations in sequential order. Within the guided map tour, there are eight locations with an image and basic information on each location.

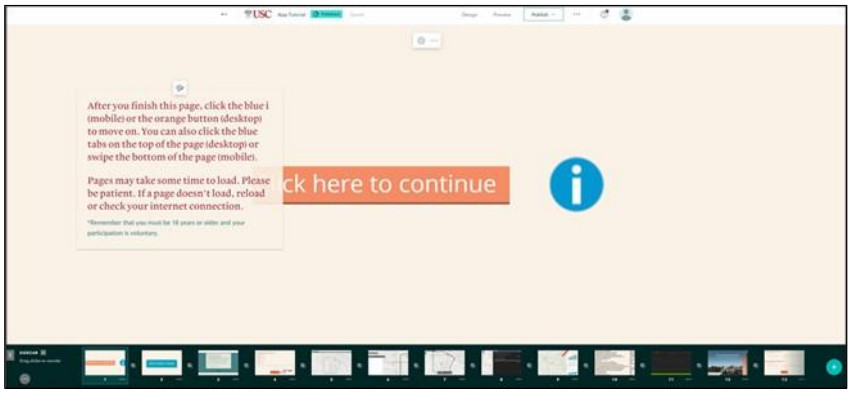


Figure 17. Sidecar content blocks

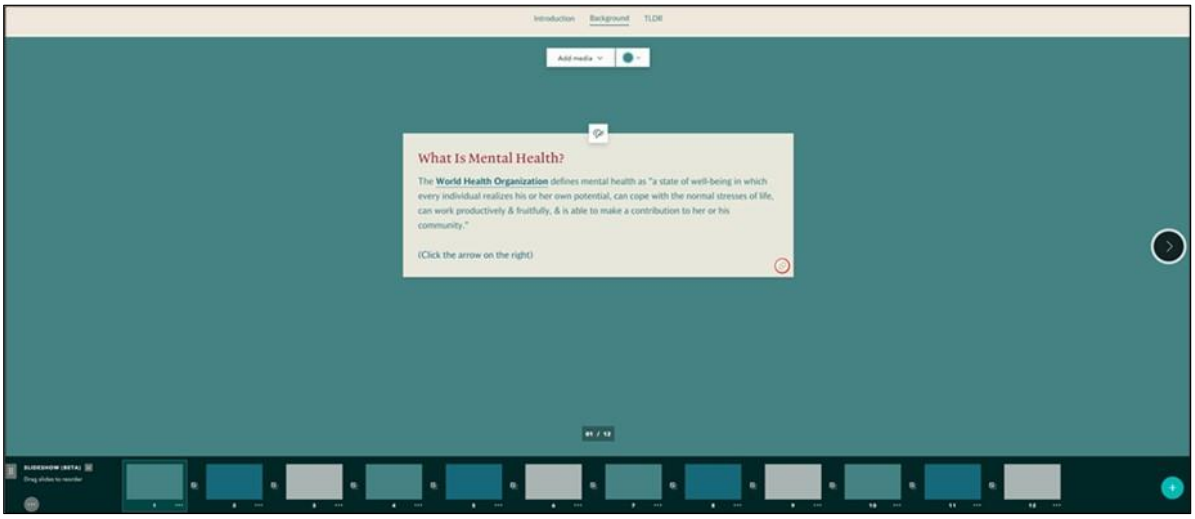


Figure 18. Slideshow content blocks

3.3.6. Survey123

Happy Traveler contains two surveys that collect data from participants. The first survey is the *Happy Traveler* survey that collects joy, mental health, and demographic data including age, gender, and race/ethnicity so that researchers and other users can analyze and draw conclusions based on the statistics tied to those data. The survey was developed using both Survey123 Web Designer and Connect. Web Designer is a WYSIWYG application that allows users to build surveys directly in any web browser. While Web Designer is easy to use, it has limited functionality. Therefore, users need to download the Survey123 Connect software to create more complex and customized surveys. Connect allows users to access to XLS spreadsheet that forms the survey. The *Happy Traveler* survey was initially created in Web Designer because it is easier, quicker, and more intuitive to use. To further customize the survey basemap and questions, the survey was downloaded in Connect and published to the AGOL cloud.

The Survey123 Web Designer survey design platform has four main sections: add, edit, appearance, and options. The Add section contains 22 different survey items that can be dragged to the survey (Figure 19). For the *Happy Traveler* survey, there are 32 questions including map, date/time, text, single choice, multiple-choice, image, and Likert scale questions. After the survey questions were created within Web Designer, the schema was edited to match the codes used in the USC WBC SWIS. Next, the survey was downloaded in Connect (Figure 20), and the study area boundary feature service layer was linked to this survey so that it could be used as a basemap in the map item. The XLSForm that contains the survey information can be downloaded in Connect to update and customize the application. Within the XLSForm, the creator can make several customizations related to survey item type, name, label, hint text, constraints, calculations, and much more.

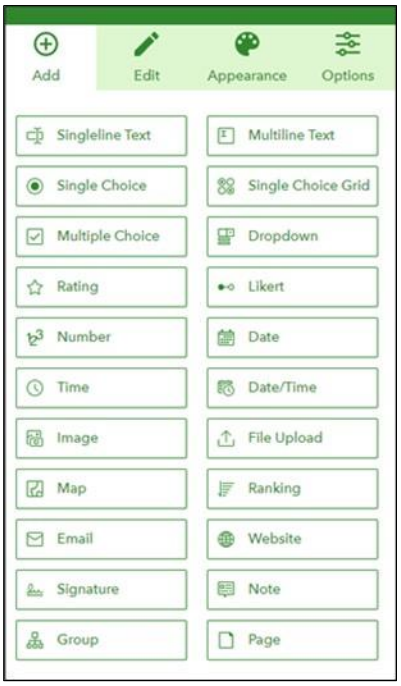


Figure 19. Survey123 item choices

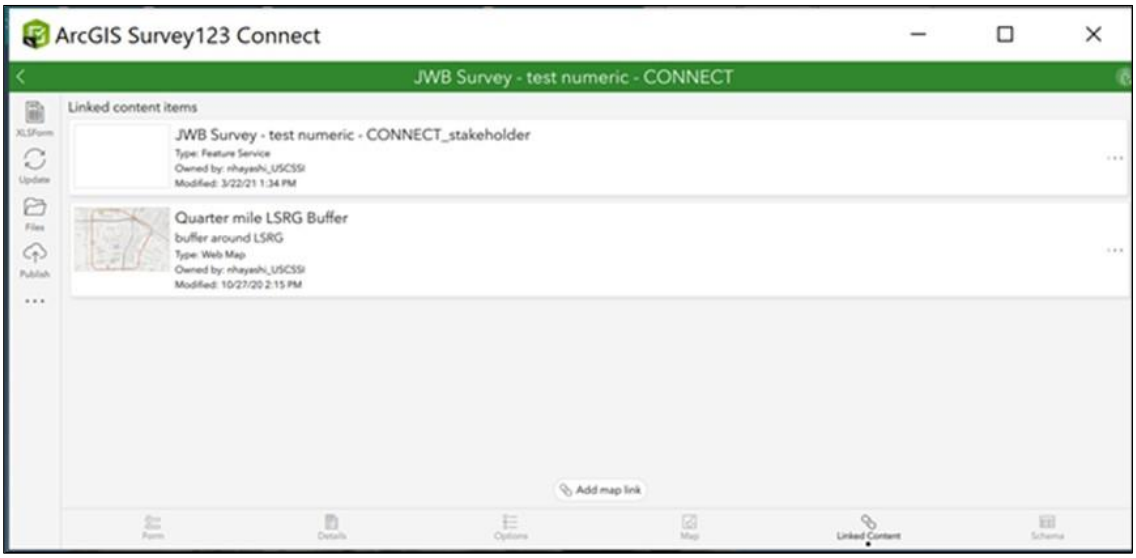
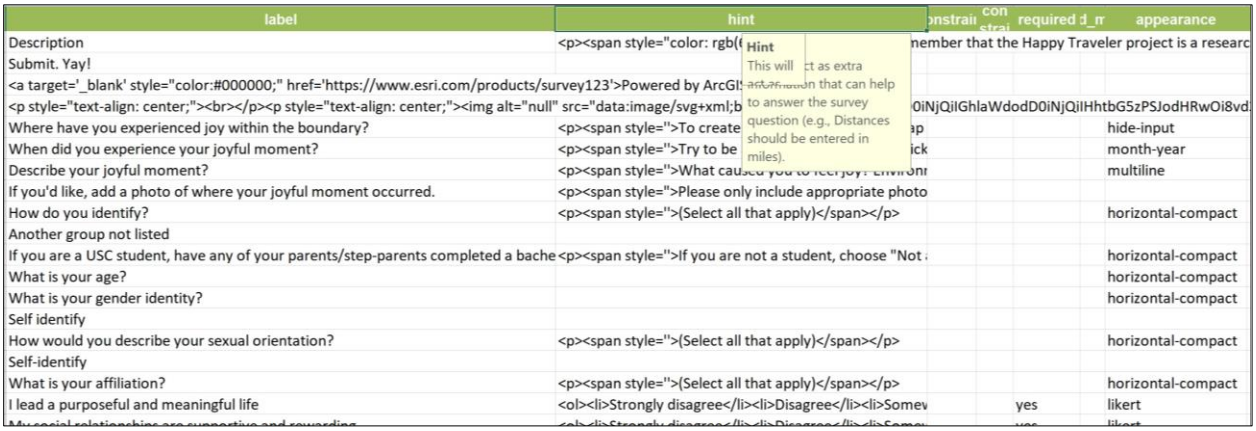


Figure 20. Linked survey content

To customize the *Happy Traveler* survey, only a few changes were made within the XLSForm to improve functionality and design. In the XLSForm, the developer can change any aspect of the survey related to the survey items, choices, and settings (Figure 21). The form is pre-populated with hints to guide the developer and a type sheet that lists all possible

customizations. The first change was for the FS and SJS field types that were changed from text to integer. In web designer, Likert scale items are automatically classified as text types, but this impedes dashboard functionality because the charts and calculations can only be used with numbers. Next, item labels and descriptions were edited using HTML when items needed to be changed and improved. Lastly, since one is not able to change the survey schema in Web Designer, changes must be made to schema names within Connect (Figure 22). Therefore, when WBC provided their SWIS codebook, the schema was modified in Connect to match SWIS.



label	hint	required	appearance
Description	<span style="color: rgb(		
Submit. Yay!			
<a target='_blank' style="color:#000000;" href='https://www.esri.com/products/survey123'>Powered by ArcGI			
  <img alt="null" src="data:image/svg+xml;b			
Where have you experienced joy within the boundary?	To create		hide-input
When did you experience your joyful moment?	Try to be		month-year
Describe your joyful moment?	What cau		multiline
If you'd like, add a photo of where your joyful moment occurred.	Please only include appropriate photo		
How do you identify?	(Select all that apply)		horizontal-compact
Another group not listed			
If you are a USC student, have any of your parents/step-parents completed a bache	If you are not a student, choose "Not		horizontal-compact
What is your age?			horizontal-compact
What is your gender identity?			horizontal-compact
Self identify			
How would you describe your sexual orientation?	(Select all that apply)		horizontal-compact
Self-identify			
What is your affiliation?	(Select all that apply)		horizontal-compact
I lead a purposeful and meaningful life	- Strongly disagree - Disagree - Somev	yes	likert

Hint
This will ct as extra
to answer the survey
question (e.g., Distances
should be entered in
miles).

Figure 21. Sample of the customizations one can make in the Survey123 Connect XLSForm

list_name	name	label
list_Ethnic	black	Black or African Ame
list_Ethnic	white	Caucasian or White
list_Ethnic	latinx	Hispanic or Latino/a
list_Ethnic	Mestizo	Mestizo/a
list_Ethnic	ME	Middle Eastern
list_Ethnic	NAAN	Native American or A
list_Ethnic	NHPI	Native Hawaiian or c
list_Ethnic	SA	South Asian/Desi Am
list_Ethnic	two_or	Two or more races/e
list_Ethnic	Unknown	Unknown
list_Ethnic	other	Another group not li
list_firstgen	Yes	Yes
list_firstgen	No	No
list_firstgen	Not applicable	Not applicable
list_firstgen	I_don't_know	Don't know
list_agecat	18_20	18-20
list_agecat	21_25	21-25
list_agecat	26_30	26-30
list_agecat	31_40	31-40

survey | choices | settings | types

Figure 22. Survey item choices in Survey123 Connect

The second feedback survey collects opinions from participants to improve future app iterations. This survey was created in Web Designer and includes email, single choice, text, and Likert scale items. For both the *Happy Traveler* and feedback surveys, the appearances were edited to match the story maps and the submission screens were customized. After each survey is created, four items are automatically created: form, hosted feature layer, stakeholder hosted/view feature layer, and fieldworker hosted/view feature layer. The form contains the survey questions and can be opened in the Survey123 application. The last three items are feature services that have different uses. The main hosted feature layer is primarily for the survey owner. The fieldworker feature service is only created when the survey is published in Web Designer first. This can be used to manage submission permissions, like adding and updating surveys, for users other than the owner. The stakeholder feature service can be used to manage viewing permissions for what users other than the owner can see. Since the other two feature services do not allow for public data collection, the main feature layer was used for the *Happy Traveler* survey so that public data collection could be enabled for mobile devices.

Two fields, Well-Being (FS) and Joy (SJS) were added to the survey data layer and calculated so that the data value equaled the sum of the items within FS and SJS respectively. Fields can be collected in the data tab of the feature service using SQL or Arcade. SQL was used for this study since Arcade required turning off the Sync and keep track of created and updated features settings. These settings were kept to manage what features were added, updated, or deleted. Other important settings within this feature layer are shown in Figure 24. Furthermore, this layer was time enabled so that the data could be visualized over time using a time slider in the dashboard.

Figure 23. *Happy Traveler* point layer editing and permission settings

The main survey feature layer was used to create a web map that would be used in the dashboard. The point layer within the *Happy Traveler* feature service was added twice to a web map, along with the study area boundary layer. The survey data layer was added twice so that the data points could be symbolized as both point features and as a heat map. The heat map symbology calculates the density of points using the kernel density estimation (KDE) method in the background and displays them from low (blue) to high (red/yellow) density. KDE is a hotspot mapping method that transforms data points into a surface by calculating the density of point features around each output raster cell (Hu et al. 2018). Hu et al. (2018) describes the KDE process as (1) "placing a kernel over a predefined area around that location, (2) assigning more weights to nearby events than distant ones, and (3) summing up the weighted events within the kernel." Within the map viewer, map pop-ups can be configured to show unique information. To create a custom pop-up, attribute expressions were created to add new information using the existing data fields. The four attribute expressions in Figure 24 were written using simple Arcade expressions (Figure 25), a scripting language that can be used on feature layers. These attribute

expressions were used to create pop-up media charts (Figure 26) that display average and individual well-being and joy scores, and to create a custom pop-up display (Figure 27).

Figure 24. Custom pop-up attribute expressions

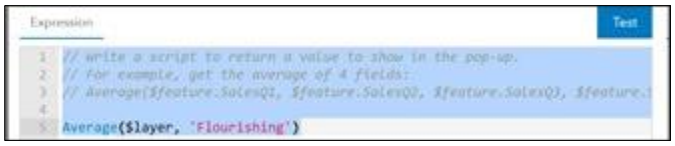


Figure 25. Average community well-being score expression

Figure 26. Pop-up media bar chart configuration

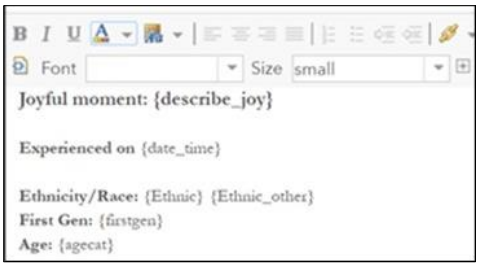


Figure 27. Pop-up content editor

3.3.7. Web AppBuilder

Web AppBuilder is a WYSIWYG application that allows users to create customized 2D or 3D GIS-based applications. Web AppBuilder has several widgets that can be added and customized to add functionality. This application has seven including a splash screen, legend, layer list, filter, query, time slider, near me, and infographics. The splash screen displays content when they open the app. This allows developers to add important information like how to use the app and what to click. The legend and layer list widgets show which layers are in the map, but the layer list allows the user to turn them on and off. The filter widget allows users to filter down the map results based on one or multiple attributes. The query widget goes one step further and only shows responses with the query inputs that are true for all parameters. Both filter and query widgets can filter responses based on demographic attributes and joy or well-being scores.

The time slider widget was enabled by making the survey data layer a time-aware layer. This means that users can interact with the layer to see data over time. The time slider was set so that users can set the time extent by month. They can also set a time extent and use the play button to make the time slider move month to month automatically. The near me widget allows users to input an address or click a point on the map to find survey responses within a certain distance. This is useful for users that want to find points near their current location or near a specific place.

The infographic widget includes 16 different graphs to visualize data. For this app, the column template was used to create 14 bar graphs, seven for joy and seven for well-being. For both the joy and well-being graphs, there is one score distribution graph and six graphs showing the average score per demographic group like age or gender identity. The distribution graphs (Figure 28) display values by feature which means each bar is an individual's joy or well-being score. Each color in the bar represents a survey item and the total bar height equals the score for that individual. The demographic graphs display average values by category and null values are ignored so that they do not affect the scores. Each graph also has a line that represents a high score. For well-being, this is 48 or more out of 56 on the scale, an average of at least 6 for all the items, and for joy, it is 66 or more out of 77.

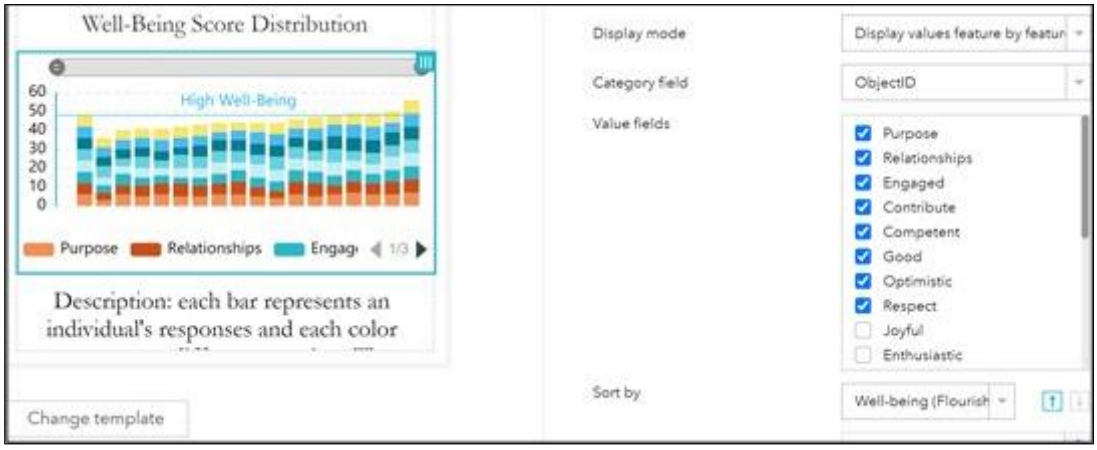


Figure 28. Infographic widget configuration

Chapter 4 Results

This chapter will describe the results of the *Happy Traveler* crowdsourcing application development and beta test following the methods described in Chapter 3. Section 4.1 will detail each of the *Happy Traveler* pages' functionality and features. Section 4.2 will include a link to the app and a tour through the application tutorial. Section 4.3 will describe the results of both the primary and secondary beta tests and the resulting feedback.

4.1. App Functionality

Each tab within *Happy Traveler* serves a different function but has data that are tied to each other. The app tutorial, information sheet, and welcome page inform the user how to use and approach the application. The survey gathers data from participants and the dashboard displays those data dynamically and in near real-time. The mental health resources page and map allow participants to learn more about mental health and joy.

4.1.1. Application Tutorial

When participants open the link to the application, they are brought to an app tutorial (Figure 29). The tone and style of the app tutorial and following pages are informal, simple, and welcoming since the main target audience is expected to be university students who use social media. This is the first page they see because while the application was made to be simple, it could be confusing for first-time users. Additionally, the dashboard is not the first page of the application because the goal is for users to learn about the study and take the survey without the bias that may develop from reading others' responses. As the user scrolls down, this page will explain the app step-by-step on how to navigate and use the application. On the top of the screen, below the banner, some tabs allow the user to navigate to each page. On the right-hand side of

each page within the app, there written prompts that make it easier to navigate. On mobile devices, the interface is slightly different because of the smaller screen size. The app tutorial describes and shows some of these differences by using screenshots (Figure 29) to show that the user can click the orange button if they want to continue to the next page or they can click the blue button if they have already been through the app and want to go straight to the dashboard. Users on mobile are also able to swipe left and right to move between pages or click a blue "i" to use the orange and blue buttons discussed previously.

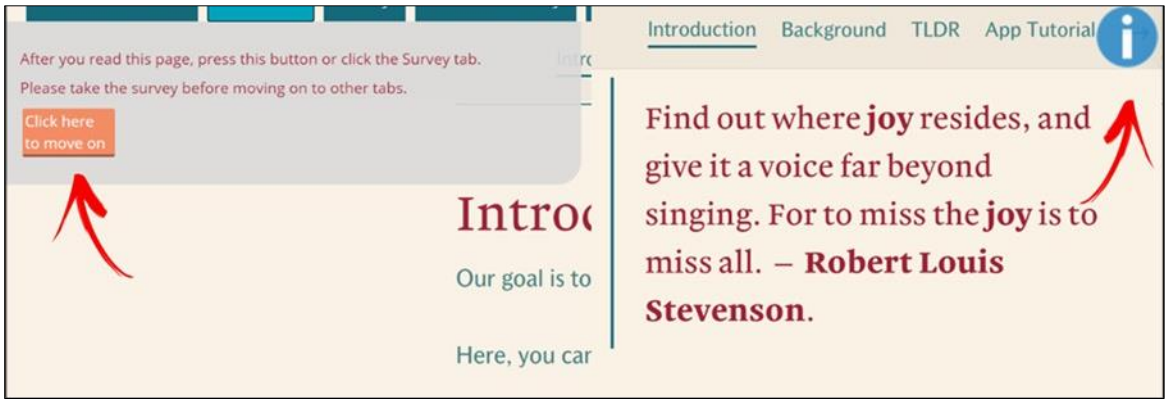


Figure 29. Screenshot comparing the buttons used to navigate within *Happy Traveler* on desktop (left) and mobile (right).

4.1.2. Information Sheet

Since this study does not collect identifying information from participants during the *Happy Traveler* survey, this study, ID UP-21-00104, was deemed exempt by IRB. Typically, studies require the collection of informed consent from the participant, but since this study has exempt status, only an information sheet is required. This information sheet (Figure 30) describes the purpose of the study, the participant's role in the study, participant confidentiality, and contact information for the primary investigator and IRB. Once the participant reads the sheet, their participation in the study implies their consent.

Figure 30. Screenshot of the information sheet on the *Happy Traveler* desktop version.

4.1.3. Welcome Page

The welcome page (Figure 31) is the point where the real app content begins. This page, and the other pages, were designed so that they were interactive, intriguing, but not so long that users lose interest. The material in this section describes the study background and gives information on mental health, joy, and well-being. Specifically, this page defines related terms, details what past research has found, explains how *Happy Traveler* fits into the research, describes USC WBC's work, and lists what users can do with the app. The content on this page was designed to inspire users to add their story to the map and to learn about the relationship between their mental health and joy.

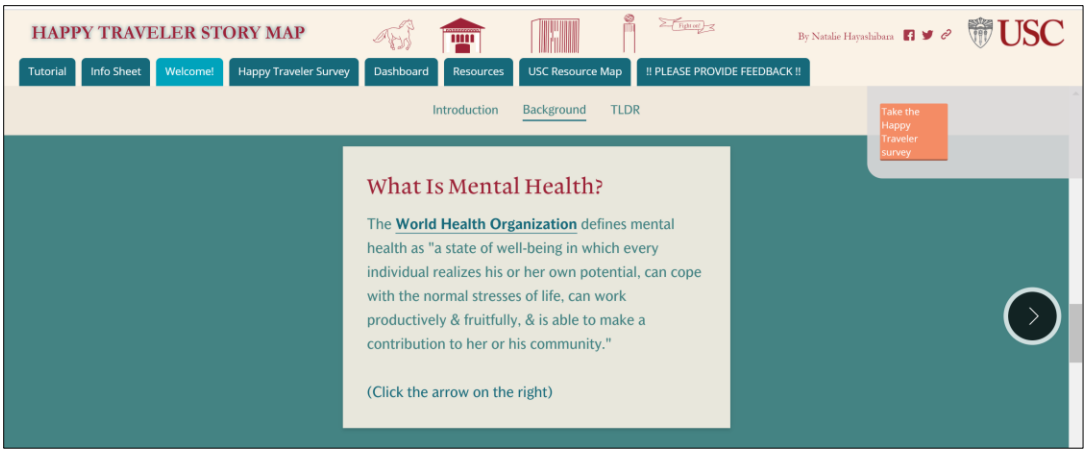


Figure 31. Screenshot of the welcome page on the *Happy Traveler* desktop version.

4.1.4. Happy Traveler Survey

The *Happy Traveler* survey includes 29 items including 1) one map that allows participants to create a point feature within the study area boundary that represents the location of their joyful moment, 2) one time and date space for users to input the time and date of their joyful moment, 3) one text box that prompts the users to describe their joyful moment, 4) one image file upload space for users to upload and image of that joyful moment or of that location, 4) six demographic questions modified from the USC WBC SWIS Codebook, 5) eight items from the FS that were used in the SWIS, and 6) eleven items from the SJS. After participants submit their survey answers, they can move on to the dashboard and immediately see their responses on the map.

4.1.5. Happy Traveler Map Dashboard

The *Happy Traveler* dashboard is the heart of the application where the data from the survey is displayed to users on a map. Since the dashboard may be overwhelming when first opened, the user is met with a splash screen (Figure 32) that gives basic information on the dashboard and how to use it. The map shows the study area and all of the respondents' points that were inputted in the survey as red dots and as a heat map. The basemap is a simple

topographic map that shows the university's features in detail, but it is not too crowded. Users can interact with the data, layers, and basemap using change the map, find trends, and discover joy.

Figure 32. Splash screen

The first four widgets (Figure 33) on the top left are used to manipulate the map by zooming in and out, returning to the home display, and finding the user's current location. To the left of these widgets, there is a search bar to search for specific geographic locations and five additional widgets: filter, query, time slider, find near, and layer list. The filter widget (Figure 34) allows users to filter out response points by demographic attribute, high well-being, or high joy. When a user uses these filters, the map shows the points that match the selection. The query widget (Figure 35) is similar to the filter widget in that users can find specific responses based on attributes. If a user wants to find all responses for Asian Americans that are between the ages of 21 and 25, they could use the query widget to find just those responses by inputting values into the text boxes. The difference is that these queries can be more specific, the output includes a new data output layer, and a sidebar appears with the attribute information.

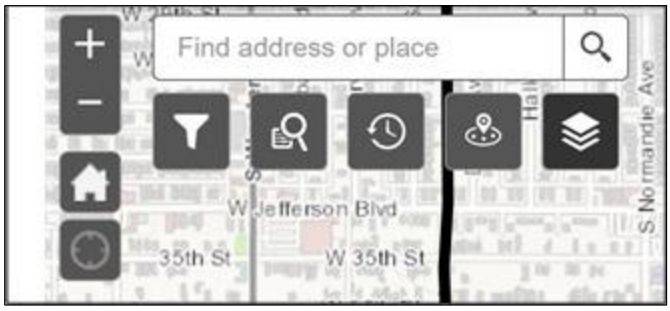


Figure 33. Map widgets

Figure 34. Filter widget with the high well-being filter applied

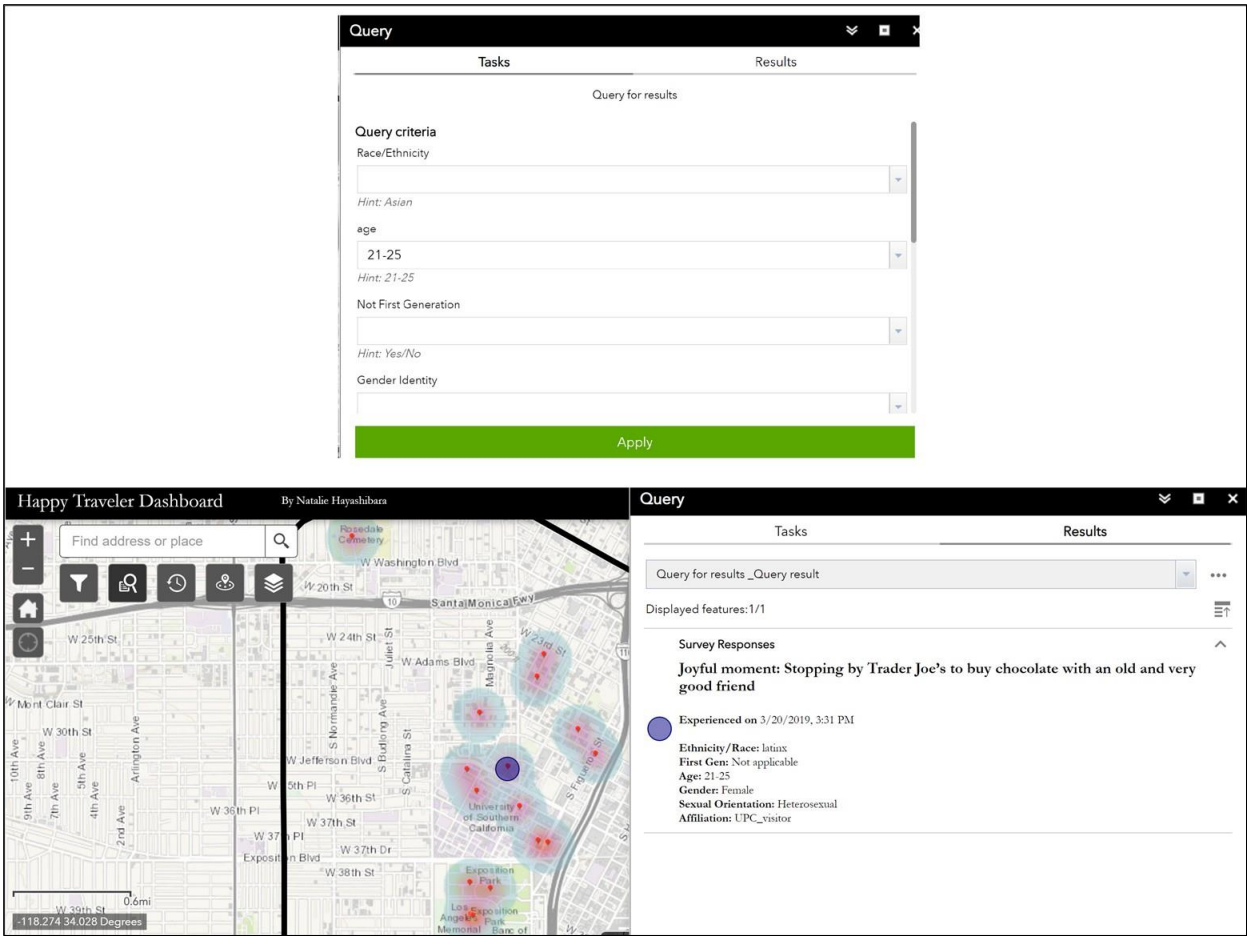


Figure 35. Query widget with the inputs (top) and outputs (bottom) for a query that specifies results with ages between 21-25 and well-being scores over 48

The time slider widget (Figure 36) is an interactive slider that users can use to move to see responses within a certain time frame. The slider was set to move in increments of one month, but the user can change it to smaller or larger time frames. When the user selects a specific time frame, the map, and charts filter to only those responses within the time frame. The slider can also be played so that it automatically moves from frame to frame. This can be useful for discerning how responses change over time like from year to year or season to season.

Figure 36. Time slider widget showing points that represent memories from February 14, 2021, to March 14, 2021

The final widgets in this section are a layer list (Figure 37) that allows the user to hide or show each of the layers and a near me widget (Figure 38) that allows the user to find points within a distance away from a specified point. The four layers in the dashboard map are 1) *Happy Traveler* Points that represent participant's joy points, 2) *Happy Traveler* heat map which uses the same data as *Happy Traveler* Points, except that instead of points, there is a heat map to show where the point densities are, 3) the study area boundary, and 4) the topographic map.

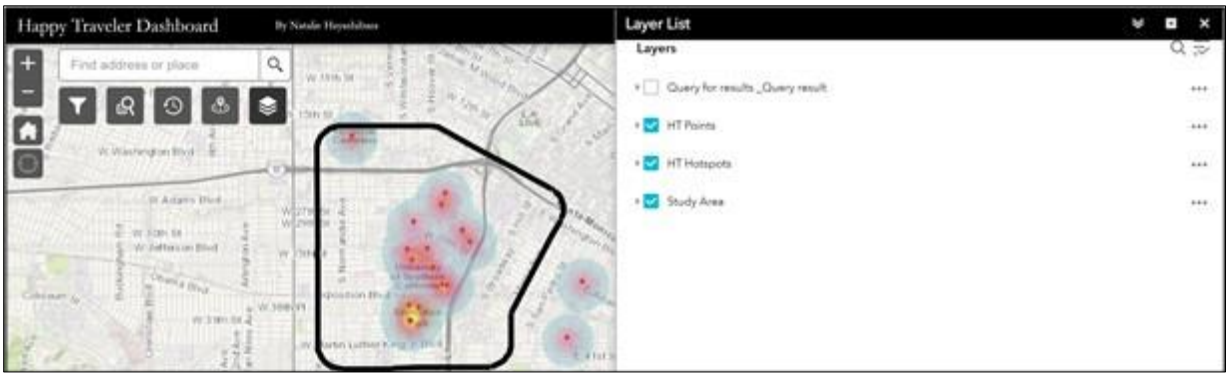


Figure 37. Layer list widget with layers including the previous query layer

Figure 38. Near me widget showing points within 702 feet from the specified location

The additional widgets in the bar above the map contain a legend, a basemap widget, and several charts. The legend shows all layers and their symbology, while the basemap widget contains several basemap options that users can change to. There are 14 data charts in total with seven focusing on the FS responses and seven on the SJS responses. The first two charts are distribution bar charts of all responses (Figure 39). Each bar represents one participant's responses, and each color represents a survey item. The blue lines on the charts represent a high well-being or joy score. For well-being, this is 48 or more out of 56 on the scale, an average of at least 6 for all the items, and for joy, it is 66 or more out of 77 on the scale. The rest of the charts show the average scores for each demographic group (Figure 40). For example, the age and positive mental health charts show the average FS score by age group.

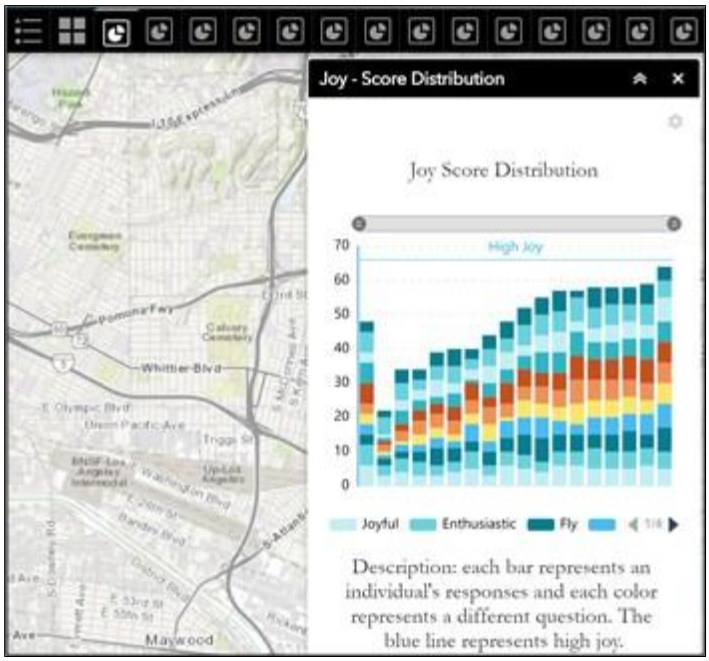


Figure 39. Infographic bar chart showing the distribution of SJS scores

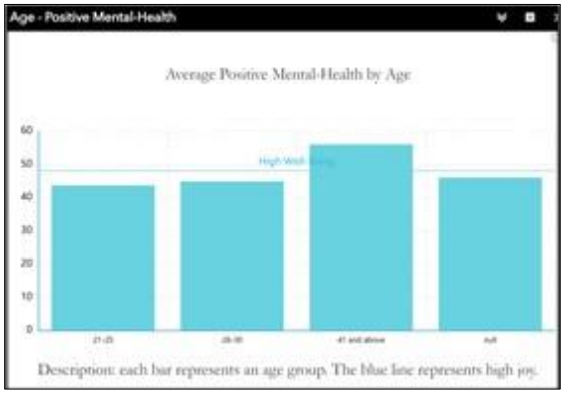


Figure 40. Infographic bar chart showing FS scores by age

When a user wants to know more about a specific point, they can click on the point and a pop-up will appear. This customized pop-up (Figure 41) contains the basic demographic information on the participant, any picture the participant may have included, and charts that show the individual's score compared to the average score for both joy and well-being.

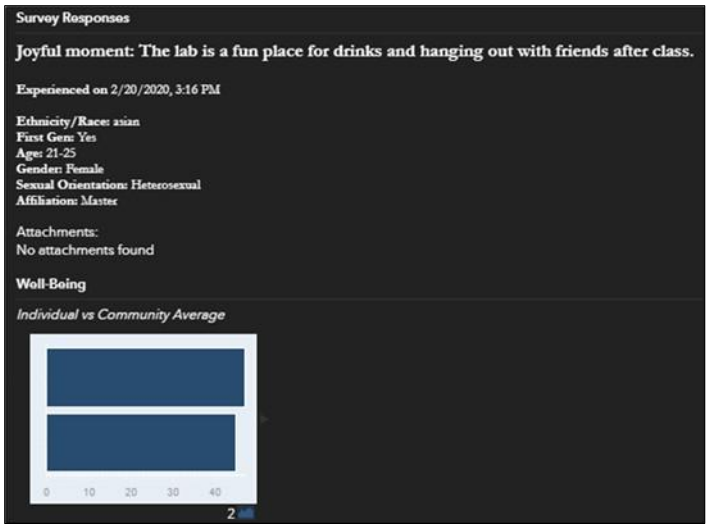


Figure 41. Customized pop-ups

4.1.6. Mental Health Resources

Many individuals who participate in this study may be struggling with mental health or interested in what resources are available. There is a list (Figure 42) of additional USC resources, general mental health resources, resources specifically for black, indigenous, and people of color (BIPOC) individuals, and USC SSI resources. Below the list, there is a map tour that takes users on a tour of USC's resources (Figure 43). As the user scrolls down the page, the map moves to a mental health resource location and presents basic information and a photo of the location. On the next tab, there is a simple interactive map (Figure 44), described in Section 3.3.2, of mental health resources with detailed information on each of the resources.

Figure 42. Mental health resource list

Figure 43. USC mental health resource map tour

Figure 44. USC mental health resources map with customized pop-ups

4.1.7. Feedback Survey

The feedback survey (Figure 45) is the final tab in the application. This page allows users to provide feedback on the app's design and functionality. The only identifying information that

is collected from the participant is their email so that they could be reached to re-test the survey and thank them for their participation.

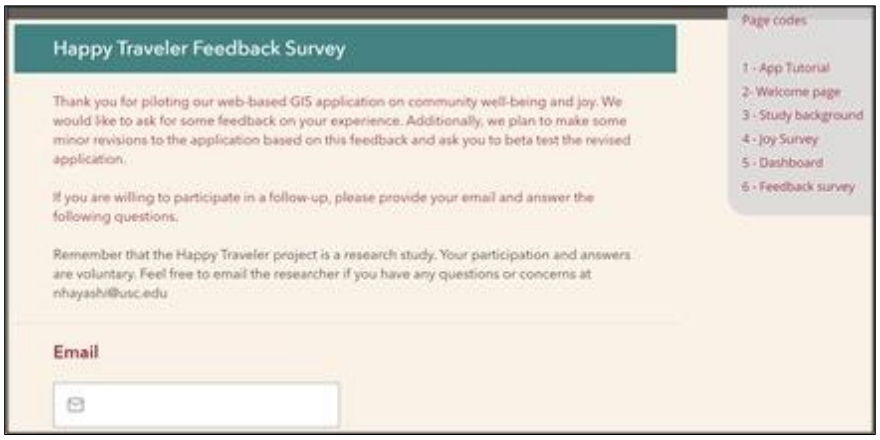


Figure 45. Feedback survey

4.1.8. Mobile Interface

The mobile version (Figure 46) of *Happy Traveler* has the same functionality as the desktop version, but there are some differences between the interface design and interface structure. The design on each page had to be optimized to fit the smaller mobile device screens. Web AppBuilder automatically updates the application format which includes changing the sidebar information to a button and the ability to swipe the screen to change pages. In the minified code, HTML and CSS were used to create style changes to customize the mobile web banner.

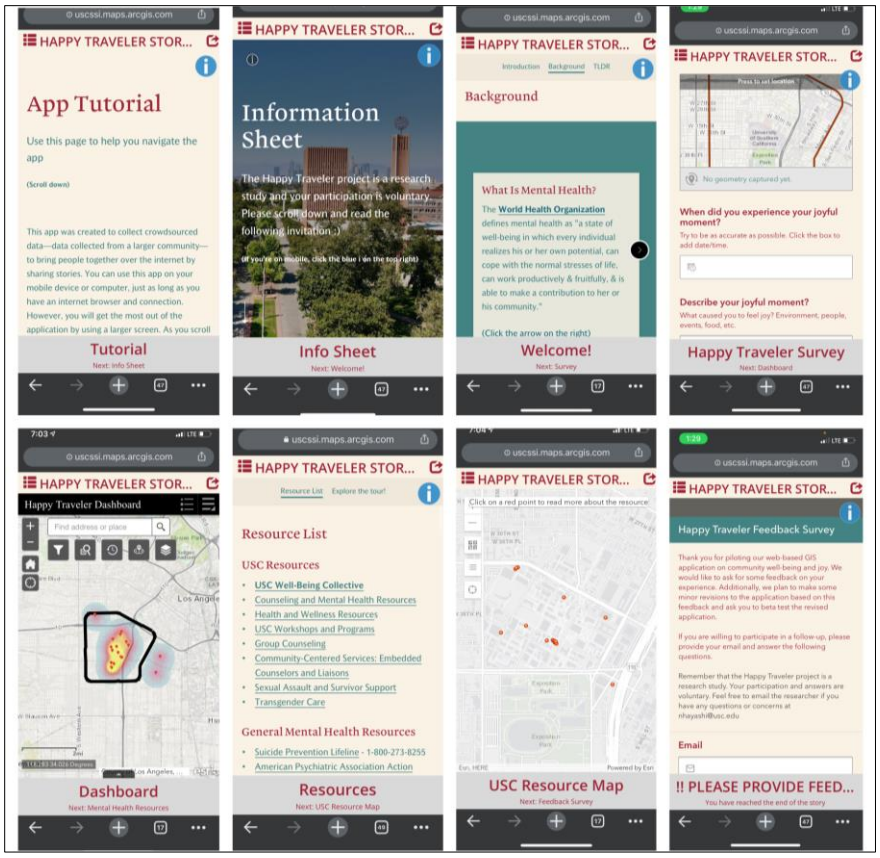


Figure 46. Mobile application pages

4.2. *Happy Traveler* Beta Test

After the IRB approved this study, the *Happy Traveler* app was beta tested to observe its efficacy and to gather feedback from the USC community. First, a sample group of students was contacted to test the application by a certain date. After the end date, the data and feedback were reviewed, and changes were made to the application. Lastly, participants in the first beta test were contacted again to re-rest or review the application changes.

4.2.1. Subjects

After the study was approved by IRB and the application was examined on both mobile and desktop devices, USC WBC was asked to send out an email containing a link and study information. 1,000 current USC students were randomly selected and contacted through a USC

WBC listserve. Participants were given two weeks to complete the first launch and one week to complete the second launch. Out of the 1,000 contacted, only 17 participated in the first launch. Of these 17 participants, only five completed the feedback survey and none completed the second launch.

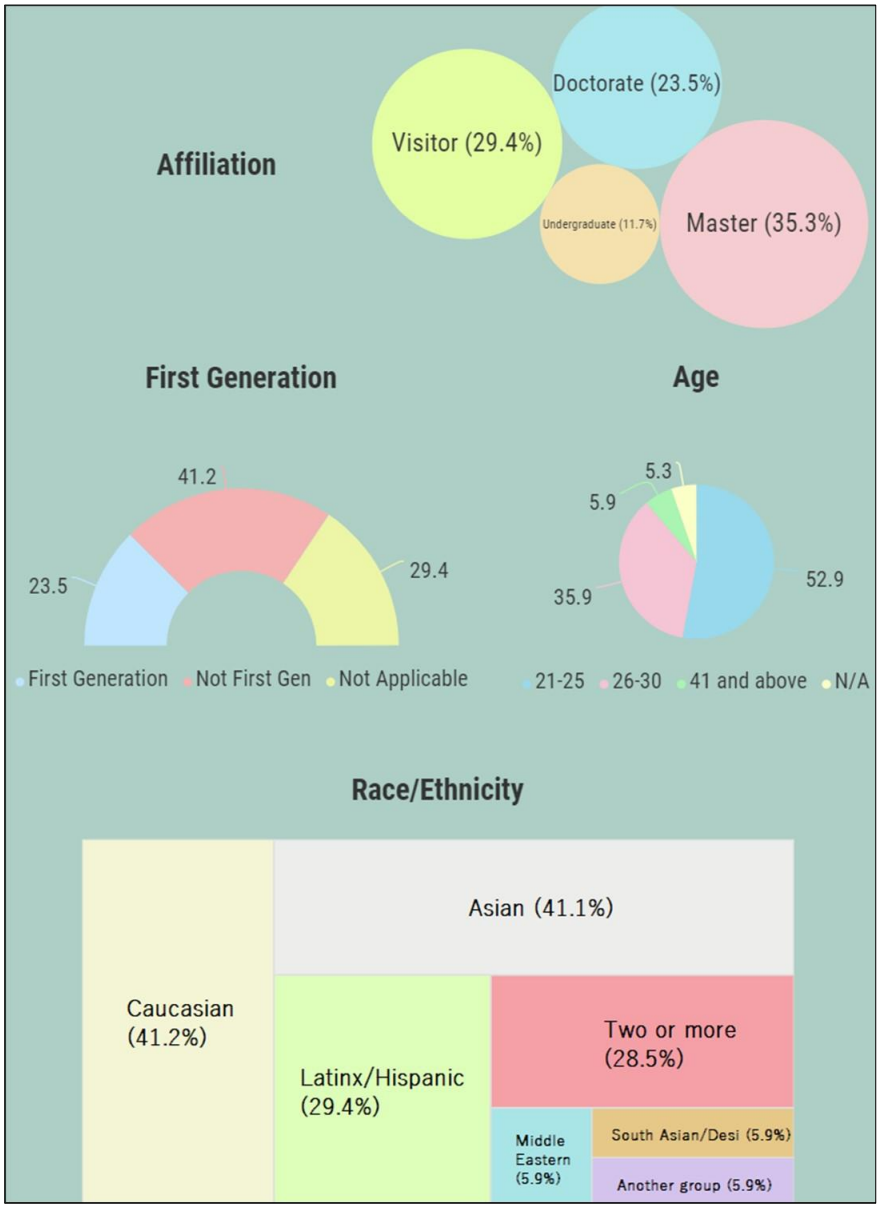


Figure 47. Sample population demographic results

4.2.2. Beta Test Evaluation

Although the beta test only included a small population of students, there were enough responses to deem the trial successful. Overall, 29.4% of participants reported a high mental health score of 48 points or higher, and zero percent reported a high joy score of 66 points or higher. A few of the results from *Happy Traveler* were similar to the 2020 SWIS results. In both studies, a positive correlation between high mental health, age, and education level, lower well-being for LGBTQ+ individuals, high levels of mental health for Latinx individuals, and low levels of mental health in Asian individuals were observed. One major difference between these studies was the mental health in cisgender women. In the SWIS, cisgender heterosexual women were the gender identity group with the highest mental health, whereas, in *Happy Traveler*, cisgender heterosexual women exhibited far lower mental health scores compared to cisgender heterosexual men.

On the dashboard map, there are a total of 17 points with 15 falling within and two falling outside of the study boundary. This is likely due to the participants accidentally skipping the instructions, thus the instructions for this section should be clearer or more pronounced. Only 25 percent of the points within the boundary are located on the USC UPC campus, with the other 75 percent in the surrounding areas. Surprisingly, only 20 percent of the points within the boundary were in green spaces like parks and cemeteries. There were four points within the boundary that exhibited high well-being. Although the high joy and well-being scores measure the present state and the joy stories are from any time, there may still be a correlation between higher scores and where moments of joy occur.

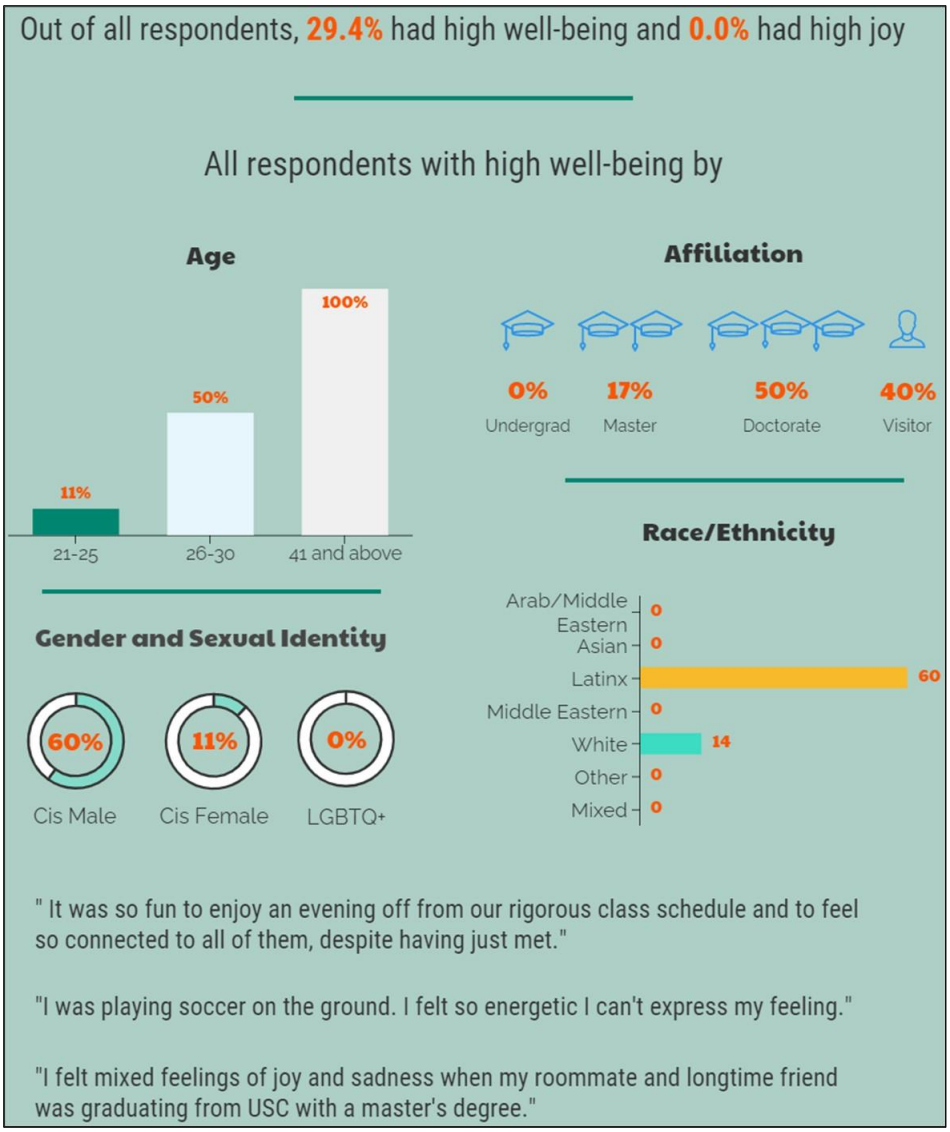


Figure 48. Beta test results

4.2.3. Feedback Survey Design and Results

The feedback survey was embedded in the story map as the last tab that users visit. This survey was developed first in Survey123 Web Designer and then edited in Survey123 Connect. The collected data is stored in a secure database on the AGOL cloud. Users were prompted to complete the feedback survey after they finished visiting each of the tabs. Five individuals completed the feedback survey at the end of the beta test. When asked what they liked most about the application, the majority stated that they enjoyed the dashboard because of how

“engaging,” “accessible,” and “straightforward” it was. Conversely, many responses noted that some parts of the application were “crowded” and “distracting.” With this feedback, changes were made to the dashboard and app tutorial to make the interfaces cleaner and simpler. One participant noted that the Likert scale survey questions felt obstructive and that they would prefer to have the order switched, but this would impede the ability to calculate final scores intuitively. Another participant noted their difficulty with adding a location on their mobile device, but unfortunately, this cannot be remediated since the developer has no control over the map design except for the basemap, map scales, data, and display. Since none of the responses mentioned any specific opinions on the dashboard functionality, items for this will be included in future iterations.

Figure 49. Beta test dashboard map filtered for high SJS and FS scores. The heat map symbology represents all respondent data

5 Conclusions

The *Happy Traveler* project attempted to develop an application that could crowdsource joy and mental health data and display it on an interactive dashboard. The beta test in this study showed that it is possible to create an online space for the USC community using GIS that could foster a community of storytelling, openness, and spatial thinking. This chapter begins with a study summary and application achievements in section 5.1. Next, 5.2 discusses the challenges faced regarding application planning, development, and launch. 5.3 outlines the application's limitations regarding application design, functionality, and scope. The final sections include a link to the code and discussions on app scalability and future work.

4.3. App Summary

The *Happy Traveler* study developed a prototype web mapping application that can collect and display data on well-being, mental health, and joy for a university community. With *Happy Traveler*, users can share their stories of joy, read other peoples' stories, disclose their mental health status, discover where joy occurs, and access mental health resources. When users take the survey, their data is populated into the dashboard map in near-real-time. In the dashboard, users can search, query, and filter data using the time slider or with attribute data like gender identity. Furthermore, there are several sets of graphs that allow users to observe the distribution of responses and trends by attribute category. The map also includes a point layer to see exactly where participants experienced joy and a heatmap layer to visualize where points are concentrated.

4.4. Challenges and Limitations

Several challenges impeded the planning, development, and launch of *Happy Traveler*. Most of the issues were related to AGOL software and functionality, but almost all were corrected. Since this application was developed using AGOL, there were many limitations related to functionality, accessibility, and design. The rest of this section further describes these issues and their remediation in depth.

4.4.1. Development Challenges

AGOL is a powerful tool for developing useful applications with little to no coding experience. However, this also means that there is little control over when there are issues, bugs, and breaks. Within both Web AppBuilder and Survey123, applications that were created for *Happy Traveler* broke or became unexpectedly deleted. Upon searching the Esri community forum, it was discovered that other AGOL users had similar issues and that there is no way to recover the lost applications. This could create a problem, described further in Section 4. if the application databases on the AGOL cloud contained vital information. After this issue was found, copies of all applications were made using both AGOL and ArcGIS Online Assistant, a website that allows users to view, update, or copy the underlying JSON for most items in AGOL or ArcGIS Portal.

Survey123 platforms give survey creators the ability to develop highly customized surveys, but there are a few limitations within the interface. Once a survey is created, there are three services automatically created described in section 3.3.4. It would have been useful to use the stakeholder, read-only layer, but with this layer, you cannot edit or add fields to the layer. Therefore, it is important to use the normal feature layer and to change settings to reflect read-only access. This survey feature layer also must be set as a public collection service, otherwise,

users cannot submit the surveys on mobile devices. Once created, surveys are automatically added to a designated folder in the owner's content folder. Unfortunately, the contents of this survey must stay within the designated folder or it will be nonfunctional. If the creator wants to change the schema or data type, this must be done in Survey123 Connect. For example, for the Likert scale data, the data type had to be changed to an integer data type, otherwise, calculations could not be performed on the layer. This platform has a learning curve, but once comfortable, the possibilities for creating unique surveys are endless.

Web AppBuilder gives creators a myriad of design and functional choices, but these were limited when creating *Happy Traveler*. The main issue encountered was related to the data infographics in the dashboard. First, there was no way to remove the presence of null values from the charts. Second, for multiple-choice items, there was no way to separate the values as individual values and were displayed as one choice. For example, if an individual reported their racial identity as Asian and white, the chart would show Asian and white as one answer instead of separating the identities into their respective groups. These data points were not recoded into separate categories since it is beyond the scope of this thesis. In the future, the WBC could collaborate with the application's database manager and discuss the survey outputs to best represent the data.

Third, the stacked bar graphs could only be sorted by a single category, instead of a total score of all items. This is an aesthetic issue that can only be resolved if the FS and SJS scores are manually calculated. The map layers have limited symbology options. Therefore, users could not change the extent of the heatmap layer. Fourth, changing the dashboard theme removed all settings, forcing the user to redo the entire interface. Fifth, the widgets are difficult to work with because they cannot be moved to other locations on the dashboard, cannot be copied, and have

limited functional options similar to the infographic widget mentioned earlier. Sixth, two fields within the map were calculated using SQL since they cannot be calculated on the fly using a stored equation. Thus, these fields must be monitored and calculated each time new data has been entered.

When designing the application's user interface, it was important to consider how and why the user would interact with *Happy Traveler*. It was difficult finding a balance between the application's functionality and usefulness, and the user interface and design. It was easy to include too many functions within the application, so careful choices on content and design maximize its accessibility and attractiveness to potential users. Since the creator had limited knowledge in HTML and CSS, it took time and multiple efforts to modify the compiled code so that it ran in a web browser.

4.4.2. Coding Challenges

The application built for this study was a beta test for an application that can collect and display mental health data from a university community. While this thesis proves *Happy Traveler*'s efficacy in achieving those goals, the application is far from complete. Due to the scope of this project, *Happy Traveler* was built with one developer with limited scripting knowledge. This resulted in the absence of inter-rater reliability, namely the degree of agreement among raters or developers in this case. Having no other developers means that there could be biases in the code and the design that have not been addressed. In the feedback survey responses, some participants noted that the interface was crowded and obstructive in some sections. Future iterations of *Happy Traveler* could be coded further with multiple developers using the ArcGIS API for JavaScript. Using the API would allow the developer to make specific changes and customizations that are not possible using the WYSIWYG apps in AGOL.

4.4.3. Launch Challenges

Before the application could be sent out to the sample population, the study had to be approved by IRB. This process was delayed due to issues out of the developer's control; thus, the launch was delayed by several weeks. In addition, IRB requested two changes to the workflow which further postponed the launch. Once the study was approved, there was only a limited amount of time for students to participate in the study, so the participant population was not as diverse or large as hoped. However, there were enough feedback responses to aid the application's development and prove *Happy Traveler's* efficacy. Future conversations with a broader range of stakeholders could further improve the application's design and functionality.

4.4.4. Accessibility Limitations

Happy Traveler was developed to be accessible to a multitude of users, but there were still many challenges related to technological and physical accessibility. First, this application is only accessible with an internet connection and while this may not be an issue since most individuals have access, not all individuals within the community have access to share their stories. Second, the application, especially the dashboard, was developed to be as simple and straightforward as possible, but it may still be confusing for users that do not have any experience with maps or data. In each tab, alternative text was used for images, but this was not possible for the dashboard. This could make it more difficult for individuals with loss of sight since there are not as many non-visual cues in the underlying design. Third, *Happy Traveler* requires access to a computer or mobile device, which may make it more difficult for individuals with loss of mobility.

4.4.5. Data Limitations

Happy Traveler is a crowdsourcing application that relies on participant responses and memories. The data from the application could potentially be used to make important planning decisions for the university; therefore, the data needs to be reliable. As discussed in Section 2.1.2, there are many pitfalls of self-report methods related to accuracy including respondents who share their stories may not remember details correctly, their current mood or location may change how they respond, or they could report purposefully deceptive information. Participant memory is not as important for the storytelling aspect of the app, but for the joy and well-being surveys, accuracy is important for measuring how well the data reflects the state of the community's mental health. Another accuracy problem originates from the creation of joy points in the *Happy Traveler* survey. The location data from the survey may not be accurate because users are not trained GIS professionals. Most users will likely use the application on a mobile device, but mobile device screens can make maps small and difficult to use. One feedback response was that the map was difficult to use on their iPhone, which could be an issue for individuals that have difficulty navigating small screens.

Although global positioning system (GPS) issues are not as important as the previously mentioned challenges, they are still important to note. If the user elects to use their current location to create a point, the phone's GPS may be obstructed by several accuracy and precision issues. First, the number of satellites and where they are located in the sky may cause reduced accuracy and high dilution of precision, an error caused when satellites are too close together, causing a loss of inaccuracy. Second, ionospheric and tropospheric delays may cause accuracy errors. Third, multipath errors from buildings or trees may reflect the signal and affect the accuracy. As stated previously, these issues are not as important since present GPS technology is

so advanced, but they could lead to minor issues if the user does not pay close attention to where their point lands on the map.

4.4.6. Potential Consequences

Happy Traveler collects point locations where users experience joy. Although college campuses are relatively small and unknown spaces remain limited, when this information becomes public, it could lead to these spaces becoming more populated. This could lead to spaces being overrun or mistreated, similar to what has happened in the last decade to the United States National Parks or vacation locations like Hawai'i. Another issue could be the endangerment of spaces shared by minority groups like locations with a high LGBTQ+ presence. In 2021, there was an increase in hate crimes and acts of bias against Asian Americans and Pacific Islanders (The White House 2021). If an individual with malicious intentions were to use this application to target areas with a high Asian American population, this could lead to community endangerment or decreased use by these communities out of fear. However, the information on this application will likely not be significantly different from what is publicly available on social media or the internet. There is also no way to filter out potentially inappropriate data, so harmful responses may not be taken down until it is seen by a manager. Finally, after an individual uses the application once, they may never return to use it again. Therefore, it may require university management to prompt community members to enter data every semester or year.

4.5. Code Availability

To view the code and changes made to the original HTML and JavaScript Object Notation (JSON), visit https://github.com/nhayashibara/Happy-Traveler-Story-Map.git. This link is also located on the mental health resources tab in the *Happy Traveler* story map. Anyone can

view the code and reproduce it as long as it complies with Esri's Apache License – 2.0. This license allows for commercial use, modification, distribution, patent use, and private use. It limits trademark use, liability, and warranty. The license specifies the following requirements for distribution which are followed in the compiled code and the GitHub repository.

4.6. Scalability and Use

Happy Traveler was developed to be able to be reproduced by other universities or organizations. This application concept can be scaled and used for any project that requires crowdsourced data. The compiled code, JSON, and survey excel files are freely available to view and use in the GitHub repository mentioned in Section 5.3. This will allow others to copy the map series story map and survey, but they will have to create the feature services, maps, and dashboard individually. Additionally, if users have access, they can use an enterprise geodatabase or Portal for ArcGIS to store the data on a local server. This allows data managers or administrators to maintain, backup, recover and scale the data and services more easily.

4.7. Future Work

The *Happy Traveler* study developed a crowdsourcing web application that collects and displays data on joy and mental health. The application allows users to be a part of the entity in pursuit of improving the collective community's well-being. Users can use their voices to share moments and locations of joy. This can provide the university with evidence on the how, why, where, when, and who of joy around campus. The data can be used to conclude how environments affect individual joy and well-being to make tangible changes. This application prototype is the beginning of what could be an effective tool for the university community, but it needs work to reach its full potential. The rest of this section discusses the ideas for future application iterations related to application content, functionality, and engagement.

4.7.1. Content Updates

Currently, *Happy Traveler* collects four main types of data: narrative, joy, well-being, and demographics. The content and length of this survey are conducive for user enjoyment and suitable data collection, but the items do not match the SWIS perfectly. In the future, USC WBC may use this application as a replacement for traditional survey methods. In this case, the survey will have to be extended significantly to include all the items in the SWIS. The content in the welcome tab and the mental health resources tab could also be updated to further align with USC's mental health goals. This may include information about specific events, resources, and research. To make these changes, it would likely require a shift from AGOL to a combination of AGOL Cloud and ArcGIS Enterprise Geodatabases.

4.7.2. Platform and Functionality Updates

Happy Traveler and its data are currently stored on the AGOL Cloud. This method provides a secure SaaS model that is scalable, accessible, and functionally comprehensive. However, as mentioned in Section 4.4.1, there are many challenges when using this development approach. If the university wanted more control over these issues and geodatabase analysis, storage, maintenance, and customization, they may want to consider integrating *Happy Traveler* with ArcGIS Enterprise. This could be done by creating an enterprise geodatabase and a database user with privileges to add data to the application online. The feature class within this geodatabase could be customized with domains and subtypes and published as a service on AGOL. This service can then be used in Survey123 by attaching the feature service ID to the survey's XLS form. This method could add security and control, but it could also be an accessibility issue for those that do not have access to ArcGIS Enterprise.

4.7.3. Future Stakeholder Engagement

This study was conducted using a randomly selected sample of 1000 students and a convenience sample of ten individuals, out of which only 17 responded within the two-week survey period. 17 responses were enough data to prove application efficacy, but if this application were to be launched by the university, a 1.7 percent response rate would not be considered successful. Therefore, this application would have to be promoted more extensively to the USC community and a wider and more diverse range of users. As of 2021, the SWIS had only been launched twice and is relatively new to the USC community. Once more data is published and the university is more familiar with the study and its potential impact, the university would have more reason to promote and support the constant use and update of the application.

In the future, a PPGIS approach would be prioritized to include the voices of the community in the application content and design. This could be done by interviewing and having meetings with stakeholders from all three user tiers. Community participation and engagement would aid in understanding and targeting user needs and concerns. By activity discussing mental health, joy, and well-being with stakeholders, could strengthen the community, interpersonal relationships, and individuals' knowledge of these topics. The poor mental health and joy scores recorded in the *Happy Traveler* beta test could be a warning that these discussions are necessary for the future. Conversely, the joyful memories that participants revealed are a sign of hope that joy can be cultivated and thrive with planning, analysis, and action.

References

APA. 2020. “Joy – APA Dictionary of Psychology.” Accessed September 16. https://dictionary.apa.org/joy.

Barton, Jo, and Mike Rogerson. 2017. “The Importance of Greenspace for Mental Health.” BJPsych International 14 (4): 79–81.

Berry, Helen Louise, Thomas D. Waite, Keith B. G. Dear, Anthony G. Capon, and Virginia Murray. 2018. “The Case for Systems Thinking about Climate Change and Mental Health.” Nature Climate Change 8 (4). Nature Publishing Group: 282–90. doi:10.1038/s41558-018-0102-4.

Bubalo, Martina, Boris T. van Zanten, and Peter H. Verburg. 2019. “Crowdsourcing Geo-Information on Landscape Perceptions and Preferences: A Review.” Landscape and Urban Planning 184 (April): 101–11. doi:10.1016/j.landurbplan.2019.01.001.

Chmielewski, Szymon, Marta Samulowska, Michał Lupa, Danbi Lee, and Bogdan Zagajewski. 2018. “Citizen Science and WebGIS for Outdoor Advertisement Visual Pollution Assessment.” Computers, Environment and Urban Systems 67 (January): 97–109. doi:10.1016/j.compenvurbsys.2017.09.001.

Diener, Ed, Derrick Wirtz, William Tov, Chu Kim-Prieto, Dong-won Choi, Shigehiro Oishi, and Robert Biswas-Diener. 2010. “New Well-Being Measures: Short Scales to Assess Flourishing and Positive and Negative Feelings.” Social Indicators Research 97 (2): 143–56. doi:10.1007/s11205-009-9493-y.

Deitz, Milissa, Tanya Notley, Michelle Catanzaro, Amanda Third, and Katrina Sandbach. 2018. “Emotion Mapping: Using Participatory Media to Support Young People’s Participation in Urban Design.” Emotion, Space and Society 28 (August): 9–17. doi:10.1016/j.emospa.2018.05.009.

De Rivera, Joseph, Lois Possell, Julie A. Verette, and Bernard Weiner. 1989. “Distinguishing Elation, Gladness, and Joy.” Journal of Personality and Social Psychology 57 (6): 1015–23. doi:10.1037//0022-3514.57.6.1015.

Dfarhub, Dariush, Maryam Malmir, and Mohammad Khanahmadi. 2014. “Happiness & Health: The Biological Factors- Systematic Review Article.” Iranian Journal of Public Health 43 (11): 1468–77.

Dhir, Amandeep, Yossiri Yossatorn, Puneet Kaur, and Sufen Chen. 2018. “Online Social Media Fatigue and Psychological Wellbeing—A Study of Compulsive Use, Fear of Missing out, Fatigue, Anxiety and Depression.” International Journal of Information Management 40 (June): 141–52. doi:10.1016/j.ijinfomgt.2018.01.012.

Esri. 2020a. “What Is ArcGIS Online—ArcGIS Online Help | Documentation.” Accessed September 27. https://doc.arcgis.com/en/arcgis-online/get-started/what-is-agol.htm.

———. 2020b. “What Is ArcGIS StoryMaps?—ArcGIS StoryMaps | Documentation.” Accessed September 27. https://doc.arcgis.com/en/arcgis-storymaps/get-started/what-is-arcgis-storymaps.htm.

———. 2020c. “What Is ArcGIS Web AppBuilder?—ArcGIS Web AppBuilder | Documentation.” Accessed September 27. https://doc.arcgis.com/en/web-appbuilder/create-apps/what-is-web-appbuilder.htm.

Esri. n.d. “ArcGIS API for JavaScript 3.35.” https://developers.arcgis.com/javascript/3/jshelp/intro_accessapi.html.

Evans, Owen. 2017. “An Introduction to Hosting Your Own Classic Esri Story Map.” Medium. January 25. https://medium.com/story-maps-developers-corner/an-introduction-to-hosting-your-own-story-map-e2450181ad2f.

Fowler, James H., and Nicholas A. Christakis. 2008. “Dynamic Spread of Happiness in a Large Social Network: Longitudinal Analysis over 20 Years in the Framingham Heart Study.” BMJ 337 (December). British Medical Journal Publishing Group. doi:10.1136/bmj.a2338.

Gallagher, Robert P. 2014. “National Survey of College Counseling Centers 2014.” The International Association of Counseling Services, Inc. University of Pittsburgh. http://d-scholarship.pitt.edu/28178/1/survey_2014.pdf.

Gao, Junling, Pinpin Zheng, Yingnan Jia, Hao Chen, Yimeng Mao, Suhong Chen, Yi Wang, Hua Fu, and Junming Dai. 2020. “Mental Health Problems and Social Media Exposure during COVID-19 Outbreak.” PLOS ONE 15 (4). Public Library of Science: e0231924. doi:10.1371/journal.pone.0231924.

Goodchild, Michael F. 2007a. “Citizens as Voluntary Sensors: Spatial Data Infrastructure in the World of Web 2.0.” International Journal of Spatial Data Infrastructures Research 2 (2): 24–32. doi:10.2902/.

———. 2007b. “Citizens as Sensors: The World of Volunteered Geography.” GeoJournal 69 (4): 211–21. doi:10.1007/s10708-007-9111-y.

Griffin, Amy, and Julia Mcquoid. 2012. “At the Intersection of Maps and Emotion: The Challenge of Spatially Representing Experience.” Kartographische Nachrichten 62 (December): 291.

Hipp, J. Aaron, Gowri Betrabet Gulwadi, Susana Alves, and Sonia Sequeira. 2015. “The Relationship Between Perceived Greenness and Perceived Restorativeness of University Campuses and Student-Reported Quality of Life.” Environment and Behavior 48 (10). SAGE Publications Inc: 1292–1308. doi:10.1177/0013916515598200.

Hu, Yujie, Fahui Wang, Cecile Guin, and Haojie Zhu. 2018. “A Spatio-Temporal Kernel Density Estimation Framework for Predictive Crime Hotspot Mapping and Evaluation.” Applied Geography 99 (October): 89–97. doi:10.1016/j.apgeog.2018.08.001.

Jeantete, Brian Adam. 2019. “GeoBAT: Crowdsourcing Dynamic Perception of Safety Data Through the Integration of Mobile GIS and Ecological Momentary Assessments.” Master’s Thesis, Los Angeles: University of Southern California. https://spatial.usc.edu/wp-content/uploads/formidable/12/Brian-Jeantete.pdf#page=58&zoom=100,93,426.

Johnson, Matthew Kuan. 2020. “Joy: A Review of the Literature and Suggestions for Future Directions.” The Journal of Positive Psychology 15 (1). Routledge: 5–24. doi:10.1080/17439760.2019.1685581.

Kitzrow, Martha Anne. 2003. “The Mental Health Needs of Today’s College Students: Challenges and Recommendations.” Journal of Student Affairs Research and Practice 41 (1). https://doi.org/10.2202/1949-6605.1310.

Klettner, Silvia, Haosheng Huang, and Manuela Schmidt. 2011. “EmoMap - Considering Emotional Responses to Space for Enhancing LBS.” http://www.geo.uzh.ch/~hhuang/pdfs/LBS_EmoMap_2011.pdf.

Lambert, Nathaniel M., A. Marlea Gwinn, Roy F. Baumeister, Amy Strachman, Isaac J. Washburn, Shelly L. Gable, and Frank D. Fincham. 2013. “A Boost of Positive Affect: The Perks of Sharing Positive Experiences.” Journal of Social and Personal Relationships 30 (1). SAGE Publications Ltd: 24–43. doi:10.1177/0265407512449400.

LaRose, Robert, Regina Connolly, Hyegyu Lee, Kang Li, and Kayla D. Hales. 2014. “Connection Overload? A Cross Cultural Study of the Consequences of Social Media Connection.” Information Systems Management 31 (1). Taylor & Francis: 59–73. doi:10.1080/10580530.2014.854097.

Law, Derek. 2019. “5 Reasons to Use Survey123 for ArcGIS.” Esri. February 6. https://www.esri.com/about/newsroom/arcuser/5-reasons-to-use-survey123-for-arcgis/.

MacKerron, George, and Susana Mourato. 2013. “Happiness Is Greater in Natural Environments.” Global Environmental Change 23 (5): 992–1000. doi:10.1016/j.gloenvcha.2013.03.010.

McGrath, Laura, Shauna Mullarkey, and Paula Reavey. 2020. “Building Visual Worlds: Using Maps in Qualitative Psychological Research on Affect and Emotion.” Qualitative Research in Psychology 17 (1). Routledge: 75–97. doi:10.1080/14780887.2019.1577517.

Oikonomidoy, Eleni, Adrienne Edwards, Matthew Aguirre, Maria Jimenez, Joseph Lykes, Mariluz Garcia, and Tamara Guinn. 2020. “Exploring the Campus Experiences of Underrepresented Low-Income College Students through Emotion Mapping.” Higher Education Research & Development 40 (May): 1–14. doi:10.1080/07294360.2020.1765318.

Pauschert, Christian, Emanuel Riplinger, Carola Tiede, and Volker Coors. 2011. “Benefits through Linking of Analogue and Digital Maps,” April. doi:10.1007/978-3-642-19143-5_12.

Poplin, Alenka. 2015. “How User-Friendly Are Online Interactive Maps? Survey Based on Experiments with Heterogeneous Users.” Cartography and Geographic Information Science 42 (4): 358–76. https://doi.org/10.1080/15230406.2014.991427.

Poplin, Alenka, Linda Shenk, and Ulrike Passe. 2017. “Transforming Pervasive into Collaborative: Engaging Youth as Leaders with GIS through a Framework That Integrates Technologies, Storytelling, and Action.” Interaction Design and Architecture(s) Journal - IxD&A 35 (January): 182–204.

Poplin, Alenka, Claudia Yamu, and Luis Rico-Gutierrez. 2017. “Place-Making: An Approach to Rationale behind the Location Choice of Power Places. University Campus Ames as a Case Study.” International Society for Photogrammetry and Remote Sensing XLII-4/W3 (September): 73–81. https://doi.org/10.5194/isprs-archives-XLII-4-W3-73-2017.

Stone, Arthur A., and Christopher Mackie. 2013. Subjective Well-Being: Measuring Happiness, Suffering, and Other Dimensions of Experience. doi:10.17226/18548.

Sugay, Celine. 2019. “How to Measure Happiness With Tests and Surveys (+ Quizzes).” PositivePsychology.Com. April 13. https://positivepsychology.com/measure-happiness-tests-surveys/.

USC Student Health. 2021. “Counseling and Mental Health | USC Student Health.” Accessed April 5. https://studenthealth.usc.edu/counseling/.

USC Transportation. 2020. “USC Supplemental Safe Ride Program.” USC Transportation. Accessed September 16.

USC Well-being Collective. 2020. “2020 Student Well-Being Index Survey Positive Mental Health Data Update.” https://cpb-us-e1.wpmucdn.com/sites.usc.edu/dist/1/292/files/2020/06/FY_20_SWIS_Positive_Mental_Health_Update_June_2020.pdf.

USC Well-being Collective. 2021. “Surveys – USC Wellbeing Collective.” Accessed March 9. https://sites.usc.edu/studentwellbeing/surveys/.

The White House. 2021. “FACT SHEET: President Biden Announces Additional Actions to Respond to Anti-Asian Violence, Xenophobia and Bias.” The White House. March 30. https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/30/fact-sheet-president-biden-announces-additional-actions-to-respond-to-anti-asian-violence-xenophobia-and-bias/.

Tulloch, David L. 2008. “Is VGI Participation? From Vernal Pools to Video Games.” GeoJournal 72 (3): 161–71. doi:10.1007/s10708-008-9185-1.

Verplanke, Jeroen, Michael K. McCall, Claudia Uberhuaga, Giacomo Rambaldi, and Muki Haklay. 2016. “A Shared Perspective for PGIS and VGI.” The Cartographic Journal 53 (4). Taylor & Francis: 308–17. doi:10.1080/00087041.2016.1227552.

Watkins, Philip C., Robert A. Emmons, Madeline R. Greaves, and Joshua Bell. 2017. “Joy Is a Distinct Positive Emotion: Assessment of Joy and Relationship to Gratitude and Well-Being.” Journal of Positive Psychology 13 (5). Abingdon: Routledge Journals, Taylor & Francis Ltd: 522–39. doi:10.1080/17439760.2017.1414298.

Watson, David, Lee Anna Clark, and Auke Tellegen. 1988. “Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales.” Journal of Personality and Social Psychology 54 (6): 1063–70. doi:10.1037//0022-3514.54.6.1063.