Humanitarian App Development

Major Qualifying Project

Advisors:

PROFESSORS LANE HARRISON AND LORENZO DECARLI

Written By:

DANIEL ALVARADO
SARAH AKBAR
VERONICA GURNAWAN
NATHAN WALZER

A Major Qualifying Project
WORCESTER POLYTECHNIC INSTITUTE

Submitted to the Faculty of the Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science in Computer Science.

10/21/2020 - 03/18/2021

Abstract

In recent years, modern gains in internet, device and application technologies have led to a worldwide revolution in how people communicate with one another. For humanitarian groups, these innovations in technology increase the potential for reaching a wider audience for both advocacy and aid. However, due to a lack of on-site technologists with domain knowledge and security concerns surrounding the creation of communication platforms for marginalized populations, strides in technology within the humanitarian and social justice space can be slow to adapt key app development innovations. Through research conducted during this project, it was evident that this disconnect between technologists and humanitarian groups can lead to applications that are too insecure to be used by humanitarian groups or cannot properly cater to the populations they are designed for. Our team proposes creating a web application framework specifically for humanitarian workers and social justice advocates. This framework highlights key concerns relating to application design, development and security for individuals looking to develop applications for humanitarian groups. For the project's domain focus, our team concentrates on the problem of resource access inequity faced by the US LGBT+ population, which was inspired by previous project work with the LGBT+ community. The developed framework subsequently led to a proof-of-concept prototype that was designed and developed by consolidating social science research with feedback from members of the US LGBT+ population across the country and cybersecurity developmental best practices. Thus, we show that by leveraging social science research with accepted software development practices, applications can be developed for unique and highly specialized domain problems within the humanitarian space.

Table of Contents

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

With the rise of the internet creating digital spaces that can be accessed almost anywhere in the world, people's relationships with technology have evolved to better suit their ever-growing communication needs. As time passes, it has become increasingly evident that the internet is quickly out-pacing other, more traditional forms of communication to become the best way to connect with others and exchange information. Countless frameworks exist to demonstrate how to build applications, from as high-level as the design and planning process all the way down to server management and cybersecurity. However, due to the growing sophistication of people's application needs, organizations are approaching a point where currently available web development frameworks are not enough to meet the demands and needs of industry-specific stakeholders. This cannot be more evident than in the humanitarian sector, where the globalization of technology means human rights' advocates can now reach the critical audiences necessary for their work; however, due to the lack of a standardized framework specifically for humanitarian application development, obstacles are reached when attempting to leverage technology for their advocacy goals.

1.1 The Problem

Advocacy for the LGBT+ (Lesbian, Gay, Bisexual, Transgender and inclusive of other minorities) community has historically been difficult for numerous reasons. First, the marginalization faced by many LGBT+ individuals persisting at each level of society (i.e. government, local community, home life, etc.) prevents advocates from being able to effectively communicate vital resources and information to everyone who needs it. In some countries, not only are there anti-LGBT+ laws that censor and target LGBT+ individuals, but the same laws prevent the implementation of many meaningful advocacy measures as they would also be censored. Second, unlike something

more monolithic as an ethnic group or religious minority, the identities of those in the LGBT+ community intersect with every other identity group in existence, which includes identities that may also be discriminated against. This means that attempts to advocate for the LGBT+ community must also provide provisions for other aspects of their identities. For instance, a black, gay man may experience not only homophobia, but racism as well. Third, there exists the issue of effective communication and resource sharing. The LGBT+ community as a whole have faced countless obstacles in order to be recognized, but the fact that LGBT+ identity is inclusive of all other identities means that the community is incredibly diverse and has different levels of access to existing resources.

The third issue of communication can be answered with the introduction of web application-development and social media. By leveraging the increasing globalization of a given country or region with an application, a much greater audience than previously thought possible can be reached. However, the other two issues outlined demonstrate that this is a problem that cannot be solved merely with a generic application. The introduction of marginalization and the way it manifests on differing societal levels, followed by the intersectionality problem of catering to an impacted minority group with widely different backgrounds, supports the need for a framework of web application development specifically for humanitarian work. Without social science research actively informing and contributing to the web application development process, any application designed for a humanitarian audience without the right knowledge base will not be able to effectively communicate with its stakeholders.

It's important to note a major problem that arises when attempting to introduce technology as a solution: the issue of having effectively secure technology that protects sensitive user data from breaches. While a web application helps to solve the immediate communication issue, it is necessary to understand the reasons behind why someone would need to access these applications in the first place. As these applications cater to communities who are more likely to have sensitive information that could endanger them if breached, security becomes the highest priority during humanitarian application development. Without rigorous security testing, sanitizing, and a system that checks for all possible threats, it would be impossible to have a successful application developed for the use of humanitarian aid and social justice. Thus, any framework that encourages using technology as a solution for humanitarian problems must contain a clause to prioritize security.

1.2 Project Work and Solutions

The project development goal was to develop and application prototype for the United States LGBT+ population that provided visualizations of LGBT+ resources and enabled users to meaningfully interact with these resources, all while demonstrating fluency of cybersecurity standards. To support an emphasized look at the problem at hand, this project limited the scope of the

research to a single country in order to maximize insights for the region. The United States was chosen for three main reasons: (1) Despite its reputation as a leader for the Western world, the United States is only ranked 20th in the world for its LGBT+ friendly track record [6]. Given a grade of B+ by Asher and Lyric's LGBTQ+ Travel Safety Index [6], the United States is a good representation of a country technically leading in pushing LGBT+ rights, but could benefit from serious improvement before it can truly be inclusive. As such, it was determined as a good case study given its existing successes and room for improvement. (2) Due to the United States' emphasis on state government, resource access varies widely across different states, which offers interesting observations when comparing multiple states on their ability to properly support their LGBT+ residents. (3) Given Worcester Polytechnic Institute's location and the limitations that the COVID-19 Pandemic set for the 2020-2021 academic year, the choice of the United States would simplify any fieldwork/outreach campaigns during the project's research phase.

In order to create a framework for future humanitarian applications, the team developed a knowledge base of information using online resources as well as data collected from the fieldwork. The fieldwork contained surveys targeted towards university students as well as humanitarian workers as they were more likely to utilize the application. The results from these surveys were then used to inform the design, features and usability of the prototype application. The prototype is a working actualization of the framework, as well as functionally a visualization of the state of resources available in the country that can be used by any advocates and interested parties alike. The prototype application was also evaluated in an evaluation study that utilized the 'think aloud' protocol, a protocol in which a user performs a specific set of tasks while verbalising their thoughts.

Results from this project can be used to inform future humanitarian application projects and provide interested technologists and humanitarian groups alike with a foundation to begin collaboration work. This project also hopes to inspire technologists to apply their practical skills in a setting that benefits social justice movements and human rights campaigns, which would encourage innovation within this specific industry and ultimately benefiting society.

Throughout the course of this project, many obstacles and challenges were encountered. These challenges are best summarized in Table 1.1.

Ultimately, this project accomplished the project objective through multiple ways, as illustrated in Figure 1.2. This project was broken into three discrete phases: (1) An initial, comprehensive research phase spanning social science and computer science disciplines, (2) A fieldwork phase targeting university LGBT+ students in the United States for both usability insights for the prototype and demographic information, and (3) An application development phase in which insights from the first two phases were used to build a proof-of-concept web prototype to demonstrate our findings.

	Project Challenges and Obstacles
1	The project was initially supposed to be conducted in Berlin, Germany with an international sponsor. This initial project would have developed the application per the sponsor's needs. Due to the COVID-19 Pandemic, the project was forced to be amended so that it could be conducted on Worcester Polytechnic Institute's campus, without a sponsoring organization.
2	COVID-19 further impacted the team's ability to communicate with one another, leading to changes to the team workflow in order to compensate.
3	Framework development was impeded by fieldwork complications stemming from the need for outreach to be conducted entirely online.
4	Difficulties with technologies used during the prototype development phase impacted the project.

Table 1.1: *Challenges and obstacles faced during the duration of the project.*

	Project Contribution Goals
1	Developed a framework in the form of guidelines (as seen in Figure 3.4) for humanitarian application development.
2	Consolidated a body of social science and HCI research with targeted surveys (aimed towards the US LGBT+ population) into a knowledge base that can be used by technologists and humanitarian groups alike.
3	Following the framework guidelines, designed and produced a prototype application that caters to the US LGBT+ population (specifically university students) and allows users to look up LGBT+ resources in any given area. An emphasis on cybersecurity best practices and appropriate map visualization was taken with this prototype.

Table 1.2: *Project accomplishments.*

CHAPTER 2

BACKGROUND

This project aimed to develop a knowledge base of research for humanitarian groups, technologists and researchers alike. To help accomplish this, extensive background research was conducted in order to contextualize the uniquely complex marginalization faced by the LGBT+ population (both internationally and in the United States), barriers to resource access in the United States, existing resources available to the American LGBT+ public and their limitations, and what HCI research currently exists to help support the community. This project drew on prior work developed by the LGBT+ community, from HCI (Human Computer Interaction) research studies to existing web technologies from which the inspiration for the project was based. It is evident that developing a product for any audience requires a thorough understanding of that audience's collective and individual experience and needs.

2.1 Marginalization of the Greater LGBT+ Community

Across the world, individuals in the LGBT+ community have long faced marginalization at both a societal and civic level, impacting their day-to-day lives, restricting (or altogether erasing) their personal freedoms, and in many cases, endangering their safety and livelihoods. The United Nations recognizes LGBT+ status as minorities protected under international law, asserting in 1994 that laws against homosexuality violated human rights [7] and formally recognizing through the Commission on Human Rights the existence of human rights violations conducted based on sexual orientation and gender identity [8]. These declarations, along with other formal definitions released from the United Nations since, acknowledged that discrimination and inequity towards the international LGBT+ community existed not just because of individuals but because of systems of oppression legalized and sanctioned in these countries.

The marginalization targeted against the community manifests in two key ways: on a leg-

islative level, in which the state presents legal barriers to the community and instigates the marginalization through policy, and on a community level, in which the society presents challenges and obstacles to the community and instigates the marginalization through societal actions. From a legislative level, it can be broken down further to explicit laws which specifically target the LGBT+ community and implicit (otherwise known as morality) laws that are vaguely or broadly defined without necessarily using LGBT+ terminology, but are still exercised against the community by the judicial system through freedom of their own interpretation. Since morality laws don't require a conservative interpretation, this leads to authorities claiming to discriminate on behalf of the government, but in actuality are exercising their own societal and personal biases to persecute whomever at their mercy.

These explicit and implicit anti-LGBT+ laws are further separated by sexual orientation and gender identity. For most countries on the ILGA's (International Lesbian, Gay, Bisexual, Trans and Intersex Association) report [1], they lack an accurate and all-encompassing language to describe the LGBT+ community due to ignorance or lack of education. Born from this ignorance are laws that not only are meant to hurt the community, but justify their own bigotry through invalid and harmful characterizations of those with differing sexual orientations and gender identities. While many countries with relatively more tolerant views of the community associate those with differing SOGI (Sexual Orientation and Gender Identity) identities under the same LGBT+ umbrella, other countries have not developed the language to do so; instead, separating LGBT+ issues into those who identify as non-heterosexual and those who have differing gender expressions. Because of this, there are unique laws that go after sexual orientation and gender identity separately.

2.1.1 Marginalization on the Legislative Level

In 2016, ILGA concluded that over seventy-three countries still criminalized or persecuted same-sex relations [1]. As seen in Figure 2.1, 35% of active United Nations member states still have laws that explicitly criminalize consensual same-sex relations, with over 31 of these states placing some form of legal barrier to expression of sexual orientation and gender identity. Within these countries, the penalties range from unjust to life-threatening; for instance, the highest consequence for same-sex relations in Mauritania and Brunei Darussalam is the death penalty. This "transgression" is defined loosely as "acts against nature with an individual of [his] sex". In 2009, Ugandan lawmakers pushed a law that would impose the death penalty on homosexuality; this, however, was shot down by Ugandan courts and replaced with other anti-LGBT+ legislation, with the most recent being the 2014 Anti-Homosexuality Act [9]. As seen in Figure 2.2, homosexuality is punishable by death in twelve countries around the world.

In addition to explicit laws against differing sexual orientations, implicit (morality) laws are used by law enforcement to enforce "correct" sexuality to the public. These laws are written generally in order to police "good, moral behavior" within its people. Countries that lack freedom

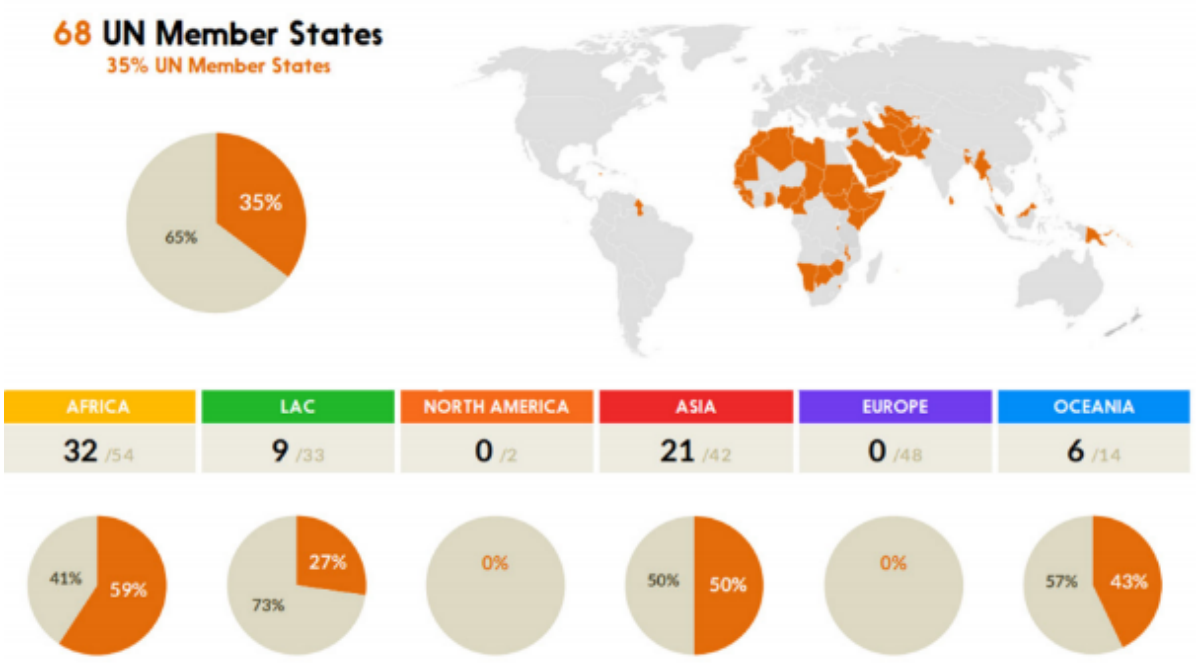

Figure 2.1: *The number of UN countries that find consensual same-sex acts illegal across all main continents. Note how both Africa and Asia exhibit more countries where some form of LGBT+ identity is illegal than otherwise. [1].*

of expression clauses and are typically more conservative will often have these laws to ensure the public maintains strict, morally upstanding behavior. However, by avoiding explicitly defining what makes an action indecent, local law enforcers can take advantage of the vagueness in order to disproportionately discriminate against the LGBT+ community. Egypt is one example of a country that uses morality laws: an “anti-debauchery” law was initially signed into legislation in 1951 for the purpose of criminalizing sex work, but is now commonly used by authorities to discriminate against suspected same-sex behavior [10]. Other forms of law enforcement abuse have been noted in Lebanon, Kuwait, Iraq and other countries, where accounts of physical violence, social and emotional torture, and community shunning are common [10].

State-sponsored discrimination, whether explicit or implicit, also targets the gender nonconforming community. From an explicit legislation perspective, there exists no legal provisions in most nations for people to change their gender on official government documents, nor allow for the categorization of a gender other than “male” or “female” [10]. This forces gender-nonconforming individuals into gender spaces they do not belong in, which carries risks of psychological consequences or threats to their personal safety. Morality laws have also been passed that would be used to invalidate and endanger the transgender community. In 2007, Kuwait signed a law that made “imitating the opposite sex” illegal. Similarly, Oman punishes “any man dressed in women’s clothing” [10]. The city of Tecate, Mexico changed their Police and Good Governance Code in 2002 to forbid “men dressed as women in public spaces” [3]. These morality laws present an nonfactual

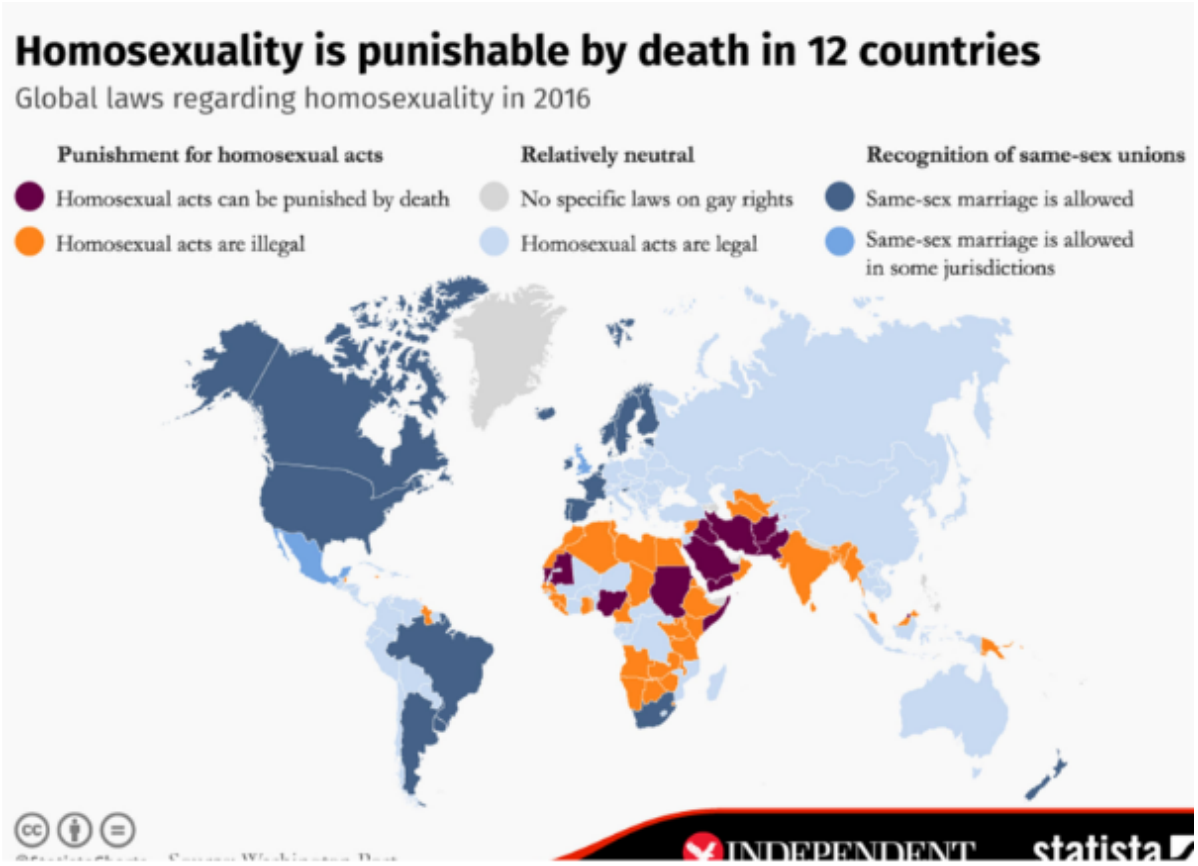

Figure 2.2: *A graphic showcasing where homosexuality is criminalized. Note the ratio between countries that recognize same-sex unions and countries that do not [2].*

and destructively limiting view on transgender rights and the rights of all gender-nonconforming individuals alike.

2.1.2 Marginalization on the Societal Level

Countries that exhibit reductive and discriminatory anti-LGBT+ laws are likely to also have hostile and ignorant views towards the LGBT+ population on a community level. LGBT+ individuals can experience a myriad of discrimination due to a combination of hostile attitudes towards "outsiders" and existing discriminatory views that persist in spite of legislative victories. One example of this is persisting anti-LGBT+ attitudes in the United States years after the legalization of same-sex marriage in 2015.

Arab Barometer, a research network that conducts various studies relating to society in the Middle East, found low acceptance of homosexuality across the Middle East, with Algeria being the most tolerant country at 26% (people deeming it acceptable) [11]. Similarly, a study by the Transgender Law Center at Cornell University found that, despite the successful passing of legal LGBT+ protections in Mexico, backlash from certain sections of the Mexican community actually

increased violence towards transgendered people, as evident from the spike of transphobic murders between 2008 and 2013 shown in Figure 2.3.

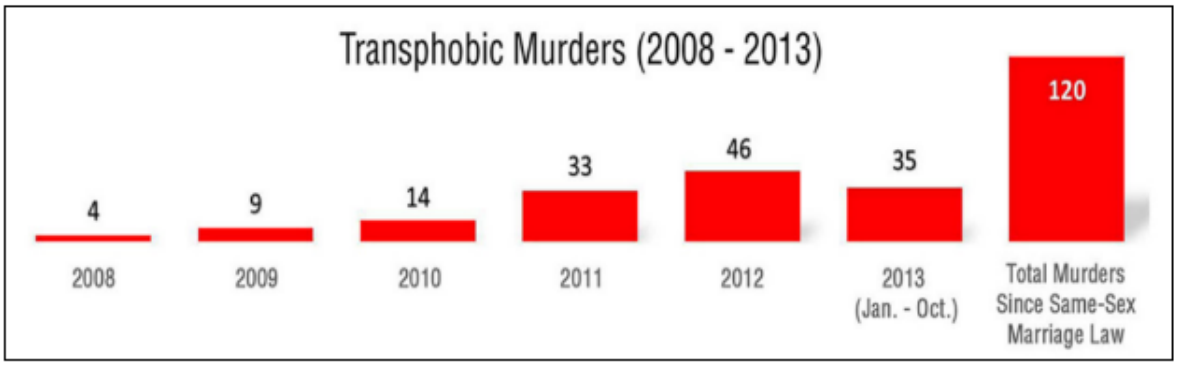

Figure 2.3: *Transphobic murders by year in Mexico [3]*

Successes in bringing about legal protections and real, positive change to the community through policy does not mean that existing discriminatory views go away overnight. It's important to note that discrimination, violence, and inequality exist even in countries that have legally recognized certain LGBT+ issues; as long as there is a need to defend LGBT+ identities anywhere in the world, there will be risks for every individual regardless of where they are located.

2.2 The US and LGBT+ Rights

The United States bears a long, difficult history with championing LGBT+ rights, with recent legislative breakthroughs including the legalization of same-sex marriage in 2015 and the repealment of the controversial "Don't Ask, Don't Tell" policy which banned gay and lesbian civilians from serving openly in the U.S. military [12]. Despite this, the United States has a long way to go before it can truly achieve equality for the LGBT+ community. Released in 2015, a report on hate crime statistics by the FBI detailed that 17.7% of hate crime victims were targeted due to their sexual orientation and 1.7% targeted due to gender-identity bias [13]. Violence against the transgender community is especially prevalent, following an exponential increase in recent years. Despite the trend of violence against members of the LGBT+ community, sixteen states in the country do not include any language recognizing gender or sexual identity under state hate crime laws, with only thirteen states covering sexual orientation at all [14]. In addition to violence, LGBT+ individuals face discrimination in the workplace, where non-discrimination laws protecting sexual orientation and gender identity minorities exist in only 20 states, meaning an employer is free to discriminate against LGBT+ individuals in roughly 30 states in the country due to the lack of available protections. Discrimination exists as well in housing, public accommodations (such as bathrooms and schools), and especially healthcare, where the inequities are especially rampant and endanger countless individuals seeking medical care throughout the

country [14].

Outside of the courtroom, stigmatization in media, local communities and even at home exist to impact the lives of those in the LGBT+ community. A study conducted by UCLA's School of Law found that about 40% of homeless youth in America had LGBT+ status, with LGBT+ youth reported to have been homeless for longer compared to non-LGBT+ youth and presenting more mental and physical health issues than their peers [15]. In all states except for eight, gay conversion therapy remains legal despite wide-ranging condemnation issued by the American Psychological Association [15]. A New York Times article by Dhruv Khullar, M.D., recognized the social, economic and health disparities faced by the LGBT+ population that are being worsened by discriminatory "religious liberty" laws being pushed by politicians at both state and national levels [16]. A study referenced by Dr. Khullar reported a 46% increase "in the proportion of sexual minorities reporting depression, anxiety and other emotional problems in states that passed denial-of-service laws" [16]. The political and social environment upon which LGBT+ advocacy and gains depend on is increasingly impacted by hostile views perpetuated by the community, which then adds to the widening disparities faced by LGBT+ individuals despite the legislative breakthroughs that have influenced the past couple of decades. These systems of discrimination and hostility must be dismantled at the highest level in order to definitively achieve equality and protections for the LGBT+ community, where inequity and discrimination persists even within the population.

2.3 Intersectionality: The Distribution of Access

Inequities faced by the LGBT+ community are not experienced equally, as evident by the critical role that intersectionality plays when speaking on LGBT+ social issues. By taking the universal struggles faced by the LGBT+ community alone, one may discredit or dismiss the compounding impacts of racism, sexism, and socioeconomic privilege. In other words, a white, cisgendered gay man in Massachusetts will face a very different set of struggles than a black, transgender woman in Alabama. It was stated previously that transgender individuals in the United States have been facing unprecedented amounts of violence recently; this epidemic of violence has disproportionately affected trans women of color, with 13 killed in the year 2017 [14]. Taking another look at youth homelessness, research from True Colors United, a domestic nonprofit organization focused on ending LGBT+ youth homelessness, found that "Black youth have an 83% higher risk of experiencing homelessness than youth of other races," making it evident that youth homelessness is affected by sexuality, gender identity, and race [17]. Struggles faced by LGBT+ individuals are inclusive of and compounded upon by their racial, gender, and socioeconomic identities, followed by where they live in the United States and the communities that support, ignore, or actively harm them. Thus, it is a precedent within social justice literature and education to look at LGBT+ issues from the lens of intersectionality, due to the inherent connectivity of

sexual orientation and gender identity with all other spheres of social justice issues.

These struggles are further complicated by the 2020 COVID-19 Pandemic, which exacerbated existing disparities for the community and uncovered new complications especially for people of colour, those with disabilities, and more. COVID-19 worsened the strain on BIPOC (Black, Indigenous and People of Color), notably Black and Latinx, queer households due to the huge economic recession kick-started by the pandemic. Existing healthcare disparities for LGBT+ individuals, especially for these households, were amplified due to the pandemic's strain on hospital capacities and struggling doctors, making LGBT+ households twice as likely to be denied medical care and four times as likely to go hungry [18]. 29% of queer households had internet connection problems for work or schoolwork at home, compared with 17% of non-LGBT+ families. These assertions are further supported by a study conducted by the Movement Advancement Project, which sought to record and quantify the disproportionate impacts of the COVID-19 pandemic on queer households in the United States. The study also found that Black and Latinx people as well as those living in the South and Midwest regions were faced with the brunt of these disproportionate impacts [19]. These impacts are explained by a number of reasons: LGBT+ and BIPOC identifying individuals have long faced disparities in healthcare access, higher rates of poverty and higher rates of victimization compared to their cisgender, heterosexual white peers [19]. To look at LGBT+ homelessness specifically, LGBT+ individuals (especially their BIPOC members) are more likely to hit roadblocks with education and employment due to rejection from their families and peers, which impacts their ability to gain housing security early in their lives. The system of oppression that many queer households are forced to face due to discrimination and violence is compounded by COVID-19, which exposed and accelerated these disparities further.

From these insights, it can be concluded that disparities and inequities faced by the U.S. LGBT+ community are wide-ranging and far-reaching, impacting those who identify with the community disproportionately to a major statistical significance. It is thus imperative that solutions presented to either assist this community or educate those within and outside of it must be reflective of the dynamism, depth and intersectionality within these struggles and perspectives.

2.4 Common LGBT+ Resources in the US

In order to alleviate the various, multifaceted issues faced by the U.S LGBT+ community, there exist a variety of resources. These LGBT+ related resources may be provided by the government or an organization at both the national and local level. Many of these resources are targeted towards LGBT+ identifying individuals themselves, which can vary from providing direct aid to building a community of LGBT+ individuals. LGBT+ resources may also provide training for other organizations and LGBT+ allies in order to increase awareness.

2.4.1 Resource Overview: Gay, Lesbian and Straight Education Network (GLSEN)

GLSEN is an organization that works to provide resources for schools at the K-12 level to encourage a safe and encouraging environment for LGBT+ students. They provide "four supports": develop supportive educators, pass and implement comprehensive policies, advocate for inclusive and affirming curriculum, and all things GSA. These supports are available in the form of resources and/or webinars and workshops available for educators, students and GSAs. GLSEN also provides research on supporting LGBT+ youth in schools and extracurricular activities [20].

2.4.2 Resource Overview: US Department of Health and Human Services (HHS)

The United States HHS provides a number of government resources for LGBT+ identifying individuals relating to health. They offer annual reports that highlight accomplishments as well as actions HHS can take to improve the health of LGBT+ identifying individuals. HHS also works to enhance the collection of health data from LGBT+ communities in order to address health disparities and inform future decisions on all levels. In addition, HHS provides enhanced resources for LGBT+ identifying individuals which include the establishment of specialized programs, resource centers and department task forces. [21]

2.4.3 Resource Overview: Gay Straight Alliance (GSA)

GSA is a non-profit organization that works to fight homophobia and transphobia in schools. Within the network, GSA clubs are student-run organizations that serve as safe spaces for LGBT+ identifying individuals. There are three types of GSAs: Social GSAs, Support GSAs, and Activist GSAs. Social GSAs help LGBT+ students meet and connect with each other on campus. Support GSAs serve as safe spaces for LGBT+ students where they can talk about various issues they are facing in school or within the community. And Activist GSAs help students improve their surroundings by raising awareness and changing policies and practices. Through these clubs, GSA Network attempts to create a broader LGBT+ community that works to improve school life for LGBT+ identifying individuals. [22]

2.4.4 Resource Overview: Out and Equal

Out and Equal provides resources and training to workplaces to create a more positive environment for LGBT+ identifying individuals. In partnering with different companies and government organizations, they provide resources that focus on different aspects of gaining LGBT+ workplace equality. Many of these resources come in the form of toolkits and guides. Organizations can then utilize these to make changes to policies and practices and increase awareness. In addition to

online resources, Out and Equal holds various events throughout the year to share best practices in creating inclusive workplaces. [23]

2.5 The Rise of Internet LGBT+ Resources

As a result of the rise of technology and the internet, the internet has emerged as a method to connect LGBT+ identifying individuals who may not have nearby existing support networks. As shown in Figure 2.4, a study performed on LGBT+ people found that a majority of LGBT+ adults in America live in rural regions. It suggests that "between 2.9 million and 3.8 million —or 15-20% of the total U.S. LGBT population—live in rural areas around the country" [4].

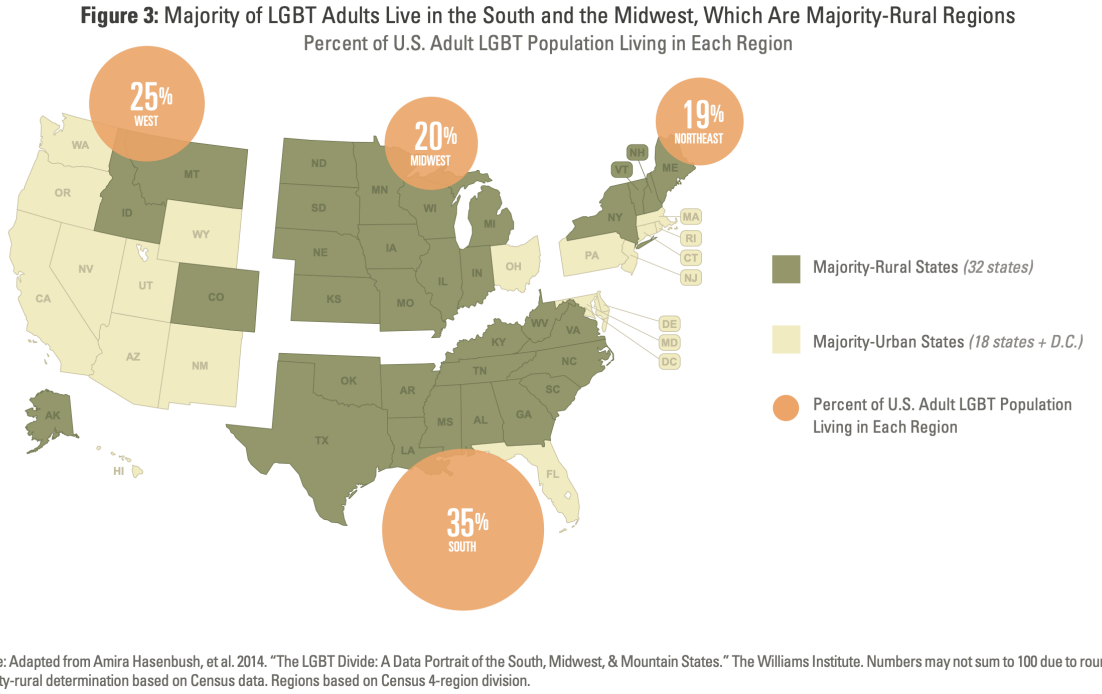

Figure 2.4: *A map of the United States with the percent of Adult LGBT+ population living in each region [4]*

For many of these LGBT+ individuals, the internet may be the only safe space. However, this is not limited to LGBT+ individuals in rural areas. A research study conducted by Tinder found that 1 in 5 LGBT+ individuals come out online. For Gen Z that number was 75% [24]. LGBT+ youth especially have been using the internet more for communication and health needs. 81 percent of LGBT+ youth have searched for health information online, as compared to just 46 percent of non-LGBT+ youth [25]. Therefore, the internet has grown to be an important tool for LGBT+ individuals to find support networks and other resources.

In order to continue providing resources for LGBT+ individuals, many organizations have evolved to provide their LGBT+ resources online. These resources may be available in the form

of online training and workshops, such as those provided by Out and Equal and GSA Network. Online resources can include online chat forums and discussion posts on popular sites like Reddit or Twitter. LGBT+ individuals can use them to build their support networks online and connect with people they would not have been able to without the internet. Due to COVID-19, larger events and gatherings such as pride events have also moved online. In Africa, where homosexuality is illegal in more than half the countries, online pride festivals have emerged as another way to connect LGBT+ individuals and allies [26]. The internet has become a powerful tool in connecting LGBT+ individuals to resources and communities they would not have found otherwise. However, there are dangers and limitations to LGBT+ resources online.

2.6 Limitations of Internet LGBT+ Resources

For LGBT+ identifying individuals who have not “come out”, or revealed their identity, to those around them, the internet is often the first safe space for them to find resources and support. Unfortunately, the internet may not truly be a safe space for these individuals. In many places, disclosing your sexual orientation can have far reaching effects [25]. LGBT+ individuals who have "come out" may be discriminated against in the workplace or even a local grocery, become estranged from families, face legal issues, and even be sentenced to death. Therefore, data privacy is imperative when it comes to online LGBT+ resources, but even security measures such as online anonymity has its complications. LGBT+ individuals may still be harassed online by malicious users and can continue to feel unsafe. According to the GLSEN, more than 42% of LGBTQ youth reported being harassed or bullied online [27]. Online harassment could then lead to detrimental effects on the well-being and safety of LGBT+ individuals. In addition to privacy and cyberbullying issues, LGBT+ resources are subject to filtering. In many places, especially on school networks, Anti-LGBT web filtering may be utilized to prevent individuals from accessing the proper help and resources [28]. By denying access to the proper resources and support networks, places that employ anti-LGBT+ web filtering risk the mental health and well-being of LGBT+ individuals. Therefore, there are various risks to providing LGBT+ resources online, and the providers of these resources need to work to minimize these risks.

2.7 HCI Research with LGBT+ Topics

Since the internet’s conception, barriers have existed to exclude a proportion of the world’s population from access. What started as a trial afforded to select engineers and military specialists turned into a modern privilege for those with the right purchasing power [29]. However, as the barriers of entry have decreased to allow for a much greater proportion of the world to access the internet, this has led to an exponential increase to the internet’s user-base, along with resulting complications from dealing with a diverse digital crowd. The question of how to properly quantify and cater to their digital experiences becomes more complex and nuanced, giving rise to HCI,

an interdisciplinary field of study that seeks to observe, quantify, and design the ways in which humans interface with the devices in their lives.

Existing HCI research on LGBT+ topics provides a lot of the background used by technologists in the humanitarian and advocacy spaces when attempting to find user experience solutions for their technology.

2.7.1 Paper Review: Intersectional HCI

Being able to define what makes a user a user is a necessary abstraction that lies at the foundation of HCI. As Schlesinger et al [30] found, previous research on identity-focused HCI studies contextualized user identity one facet at a time. This paper provides an argument for the inclusion of intersectionality when defining users in an HCI context; in other words, creating a framework "for engaging with the complexity of users'–and authors'–identities, and situating these identities in relation to their contextual surroundings" [30]. Schlesinger et al argues that technology developed to cater to any sort of identity-specific domain needs to account for the intersectionality of that identity in order to work for the greatest proportion of users with that identity. By understanding how the identity of the user is represented, technologists can cater to them far more effectively.

2.7.2 Paper Review: Codesigning Emancipatory Systems

As part of the HCI research, existing frameworks for mobile application development were examined in the context of LGBT+ issues. Pereira et al [31] looks into existing failures and limitations in previous application development projects in attempts to cater to the LGBT+ population and found these major observations:

1. Content moderation and privacy were the No. 1 biggest concern with affecting user experience.

2. Societal prejudice translates to online interaction, leading to a need for information systems that stand for a moral ground (cannot remain unbiased)

3. In applications that give users a voice, moderation is required in controlling the impact of that voice. In other words, a skilled and engaged group is necessary to mediate access to sensitive information in order to prevent malicious intent.

4. Community features that lead to users being able to maximize exchanging commonalities were found to have higher positive feedback than community features that only allow users to relate to one another in one context. In other words, the incentive to engage in a forum setting increases as the number of opportunities to exchange information (for the user) increases.

All things considered, this framework emphasizes application development that relies on a semioparticipatory approach. This concept, also called participatory knowledge construction, relies on participants with domain knowledge (for this project, LGBT+ identifying users fitting the profile of the stakeholders) to drive the design of the application project, with the application developers acting as a vehicle to deliver their input through development.

2.7.3 Paper Review: Designing Technology to Support Safety for Transgender Women & Non-Binary People of Colour

Starks et al [32] examined the critical experiences faced by transgender women and non-binary people of color and designed U-Signal, a wearable technology with an accompanying mobile application prototype to increase personal safety and decrease safety concerns. By researching the disproportionate violence and discrimination that trans women and non-binary POC experience, they sought to consolidate the experiences of advocates, social science researchers, and technologists and create a wearable tech solution to this social problem [32]. Their methodology includes preliminary interviews with trans and non-binary participants to design their initial prototype, then a second stage of in-depth interviews for more design insight that led to a refinement of their prototype. They found that there were no applications catered towards personal safety for trans people of color; in fact, no existing safety applications had provisions for the unique needs faced by trans people of colour, suggesting that personal safety apps do not effectively cater to their entire audience.

CHAPTER 3

FUNDAMENTAL CHALLENGES IN HUMANITARIAN APPLICATION DEVELOPMENT

Before building a prototype for a humanitarian and social advocacy context, it was important to develop a knowledge base of the complex issues with the LGBT+ population. By identifying these challenges and leveraging them with firsthand perspectives from the fieldwork, a series of guidelines were developed that (1) can be used by advocates and technologists as a framework for their own humanitarian application development projects and (2) was used by the team to develop a working prototype within the social justice domain. This research led to the construction of the prototype objectives, which is what the construction of the surveys was based upon.

The steps to identifying challenges and developing the scope of this project were as follows:

- **Background Research**: A body of research was developed that relied on insights, studies, and perspectives from the social science community, the humanitarian and advocacy community, and the HCI community of researchers. This established a series of preliminary application development guidelines derived from existing projects, research, and reports.

- **Project Scope Direction**: From the background research, objectives were outlined for the application prototype, and the prototype's purpose was created. The prototype was used as a demonstration of the guidelines.

- **Survey LGBT+ University Students in the US**: The next step was to iteratively develop and then deploy a survey to university students in the United States seeking their personal experience and expertise with LGBT+ social issues. These surveys were meant to validate the preliminary guidelines developed after the background research and provide the project with feedback on the prototype design.

- The surveys sought demographic information, gauged students' individual experience with resource inequity in their current locations, and performed a usability survey with the proposed prototype features.
- The usability portion of the survey was designed to measure the efficacy of the prototype design and allow for feedback used to inform subsequent design iterations.

This research methodology allowed the team to not only develop substantial background knowledge on the nuances of what the LGBT+ population experiences, but provided the team with the tools to develop a framework for humanitarian application design best practices.

3.1 Investigation and Research

3.1.1 Development of Humanitarian Application Guidelines

Developing the background for the project was performed using a multifaceted approach. The core problems and experiences faced by the LGBT+ population were examined through social science research, gathering insights using a funnel approach that started at an international level and ended with a focus on the United States, the location this project is based on. Then, secondary research was performed to provide context to the issues that were found to understand why these problems exist. Then the most common, existing LGBT+ resources on the internet for the United States were explored in order to further contextualize the user experience of LGBT+ identifying individuals based in the country. Finally, HCI research and existing frameworks produced by researchers, advocates, and technologists looking to characterize user experience and identity issues were utilized to find tech solutions for the LGBT+ community. From this, a series of preliminary guidelines were developed that can be used to inform humanitarian application research and development, as seen in Table 3.1. Creating these guidelines was motivated by a need for a simple, easy-to-reference way of digesting the knowledge base's key framework insights. This way, it is possible to justify the framework that was developed and underline the main considerations.

Preliminary Guidelines for Humanitarian Application Development	
1	Security is the most important consideration when developing technology for vulnerable audiences.
2	Identity-first applications must be inclusive of the user's full identity profile as opposed to focusing only on one. This concept is called intersectionality.
3	Application development must contain elements of participatory design and involve the stakeholders during the design stage.
4	Humanitarian application development must prioritize the perspective of the involved humanitarians and lend support to the technologists with domain knowledge.
5	Continued support for the application (post-production) requires a commitment to community mediation.

Table 3.1: *The preliminary guidelines developed after conducting the background research.*

3.1.2 Development of Project and Prototype Goals

The background research underlined that there is an epidemic of resource access inequity present in the United States. Disproportionate, hostile attitudes towards the myriad of identities under the LGBT+ umbrella, many unique to specific locations, were found to be rampant across the United States, making it difficult to have reliable resource access depending on the locations. The most mainstream, available LGBT+ resources that were found either relied on local partnering groups or only offered broad support as opposed to individualized support. Finally, the HCI research supported utilizing technology to serve better, more specialized support to the community (while recognizing intersectional identities), with a few caveats concerning security and outreach. This lead to the following conclusions:

Conclusions	
1	There is a resource inequity problem in the United States. Due to intersectionality issues, locations within the country, and variable views on LGBT+ rights, people's access to resources in this country are not created equal.
2	Due to the sensitive nature of LGBT+ identity, the proposed solution must follow best security practices to ensure the users' experience with the prototype does not compromise on their safety.
3	To best support the LGBT+ population, the proposed solution sought to (1) Answer the resource inequity issue in the country and (2) Provide a way to visualize the resource inequity issue in the country

Table 3.2: *Preliminary project conclusions.*

With these conclusions in mind, prototype goals were developed:

Prototype Goal
To help democratize access to LGBT+ resources and information in the United States, as well as raise awareness on issues surrounding access inequity that affect countless LGBT+ identifying individuals across the country.

Table 3.3: *The prototype goal.*

The prototype goal was executed by (1) providing LGBT+ identifying users, particularly students studying in new towns/cities, with a centralized database of LGBT+ resources in their current locations and (2) providing advocacy groups (and other related parties) with a visualization on LGBT+ related resource availability across the United States.

The next step was to conduct fieldwork in support of this prototype goal, as well as validate the preliminary guidelines and research findings.

3.1.3 Surveying LGBT+ Individuals for an Informed Design

Having developed the background research and created these preliminary guidelines, the validation and support of these guidelines was sought through fieldwork. As Guideline #2 underlines the importance of participatory design, a survey was released that was used to not only collect demographic data and opportunities to validate the background research, but also provided space to critique and inform the design of the application prototype. These surveys furthered our own understanding of the issues surrounding resource access inequity and personal safety in the LGBT+ community, as well as validate the development process.

The survey targeted LGBT+ university students as they were most consistently likely to have migrated to a new location outside of their home town and were thus dependent upon the strength of that new location's LGBT+ outreach services. The survey was developed using the survey platform Qualtrics and distributed primarily through email. Distribution began by reaching out to college LGBT+ clubs and groups asking them to share the survey with their members. Additionally, members of Worcester Polytechnic Institute's faculty were contacted to forward the survey to any LGBT+ student groups they are involved with. The full list of survey questions can be found in Appendix A.

3.2 Research Results

Using the results from the surveys, motivations were developed for each of the preliminary guidelines, creating the final guidelines list as evident in Table 3.4.

Guidelines for Humanitarian Application Development	Motivations
1. Security is the most important consideration when developing technology for vulnerable audiences.	Marginalized populations are much less likely to take advantage of technology at the risk of privacy and data infringement, which could easily compromise their safeties and livelihoods.
2. Identity-first applications must be inclusive of the user's full identity profile as opposed to focusing only on one. This concept is called intersectionality.	Identity-related politics and issues lie at the junction of a person's identities, not just the *main* identity at hand. LGBT+ advocates must care not only about a person's LGBT+ status, but how that status compounds with their racial/ethnic backgrounds, religious identities, socioeconomic backgrounds, etc. Attempts at advocacy will be limited to the profile created for the user, so it is better to have an all-encompassing profile as much as possible.
3. Application development must contain elements of participatory design and involve the stakeholders during the design stage.	Humanitarian applications fall under the category of "identity-first" or "domain-specific" applications. These types of applications emphasize a proper characterization of their audience as well as their direct involvement in the design process in order to succeed.
4. Humanitarian application development must prioritize the perspective of the involved humanitarians and lend support to the technologists with domain knowledge.	Humanitarian workers, advocates, social science researchers and the like are the experts. Technologists interested in creating technology for this audience must have the informed experience or perspective to do so.
5. Continued support for the application (post-production) requires a commitment to community mediation.	While community engagement is encouraged, moderation is vital. Communication platform designs cannot commit to being unbiased if they strive to uphold some moral ground. Positive or educational user voices should be supported while malicious or hurtful user voices should be filtered in the interest of fostering a safe space.

Table 3.4: *The final guidelines for humanitarian application development along with the motivations behind each suggestion. The guidelines were informed by the results of the survey.*

3.2.1 Survey Results Breakdown

50 responses from university students were recorded about the LGBT resources in their area and for their opinions on features for the application The completed survey can be found in Appendix A. The majority of the survey respondents were undergraduate students between the ages of 18-20 who identified as part of the LGBT+ community. Responses were expected to be influenced by the type of location respondents lived in. Participants from rural areas were predicted to

rate available resources and LGBT+ friendliness in their area lower compared to the ratings of participants living in suburban or urban areas. On the contrary, the survey results demonstrated suburban areas actually had the lowest ratings among the three types of locations as displayed in Figure 3.1. This discrepancy is probably due to the fact that the amount of responses received from rural areas was much lower than the others, amounting to only around 10% of the total responses as shown in Figure 3.2.

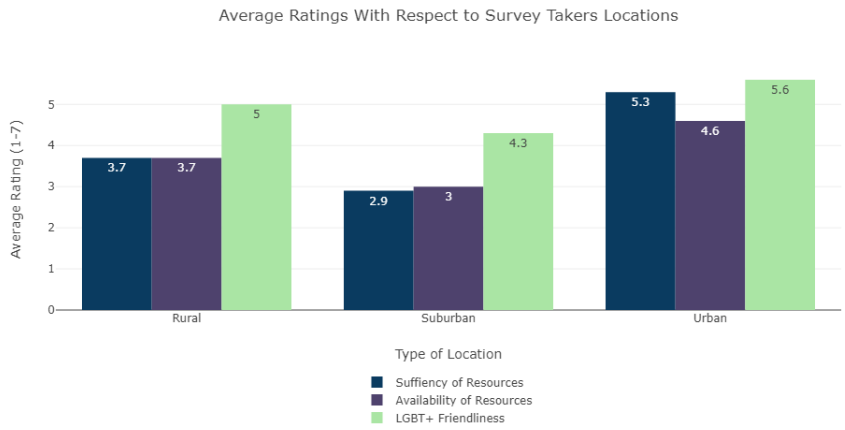

Figure 3.1: *Responses from suburban and rural locations had lower ratings than their urban counterparts.*

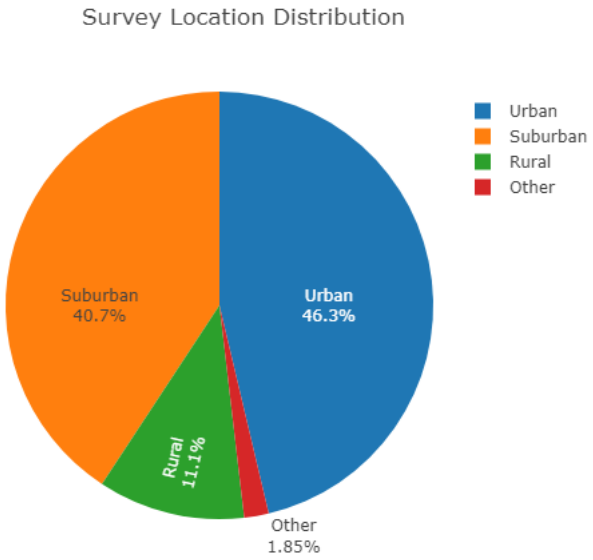

Figure 3.2: *The majority of survey takers were from urban or suburban areas while only a few were from rural areas.*

When asked about the sufficiency and availability of LGBT+ resources in their area on a scale of 1-7, where a higher number indicated more availability, the majority of responses lay around 4-5 while the remaining responses were split evenly above and below this margin. The responses received show that although not everyone has an issue with the sufficiency or availability of LGBT+ resources, there is still a need for the application so that resources can be consolidated for those affected as shown in Figure 3.3.

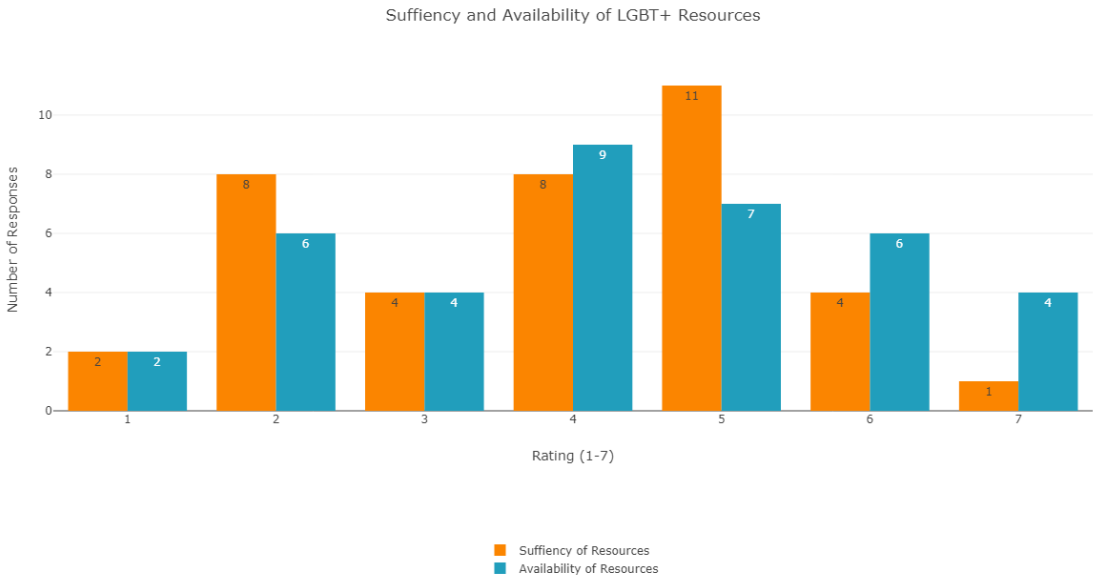

Figure 3.3: *The results displayed indicate that resources are regularly sufficient and available for the 50 survey takers. There are still many responses that indicate a lack of good resources.*

When asked about the usefulness of specific features on the application, the bulk of responses, over 80%, felt that the features would be useful for them as seen in Figure 3.4. One survey taker commented, “The fact that you can only see things once you’re in a location makes it so people can’t plan ahead for travel or moving”. This comment directly affected the application design as it can be important to be able to see areas outside of your own location. The map features were updated to showcase all resources rather than only resources in proximity to the user.

The sufficiency and availability of resources were generally good, but there was a fair amount of responses where this was not the case, especially in suburban areas. One of the most important aspects of the application was security which was highlighted in the question which asked for any comments or concerns about the potential features for the application as seen in Table 3.5. Given the responses expressing lack of known resources, and comments about security, the survey demonstrated that there is a need for the application and that the safety and security is a top concern from potential users of the application

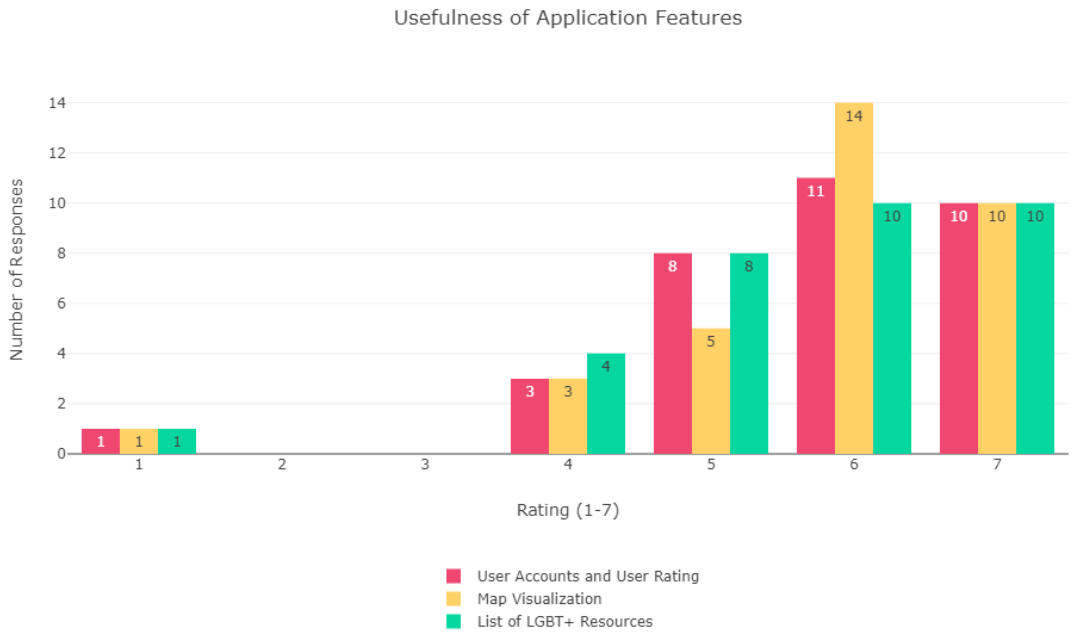

Figure 3.4: *The majority of survey respondents felt that the features proposed for the application would be useful.*

Comments and concerns regarding proposed application features
"It may be helpful to make sure users can't see each other's identities/profiles for safety reasons. for the same reason, maybe this app could be discrete/not look or be named so blatantly so that closeted people can have it more safely on their phone"
"I'm concerned about anti-lgbtq+ people accessing the app and using it to harm people and safe spaces; I want these resources to be available to our community, but the possibility for misuse worries me. "
"I would be very concerned about people with negative/violent intentions using the app to find places to target"
"My only concern about community development would be homophobic people who might gain access to the system, and by that what counts as a registered user and how to determine that. "

Table 3.5: *Quotes from responses given in the survey that displayed concern for safety and security*

CHAPTER 4

APPLICATION PROTOTYPING: DESIGN DECISIONS

In order to produce a practical, useful application, it was necessary to determine what type of application would best suit the needs of LGBT+ users in the United States. Mobile and web applications respectfully have different security concerns, different usability standards, and different relationships with the greater public. Mobile applications are faster and more efficient by some measures, but require downloads and limit the pool of users to those with a mobile device. Web applications do not require downloads and can be accessible by anyone on most devices with a web browser, provided they are connected to the internet. In the interest of providing access to the most number of people, as well as usability and lifespan concerns with mobile applications, a web application prototype was chosen.

Initially the application was to be developed using native JS for the frontend, Firebase as both the backend and database, and a combination of Tableau and MapBoxGL for the visualizations. After testing native JS, it was decided to make use of React.js, a JavaScript framework specifically used for building interactive user interfaces. Popular frameworks such as React.js have active support communities, offer flexible design and user interaction options, and reflect an industry standard for building modern web applications. In the interest of providing knowledge for future humanitarian application development projects, it was desirable to use React.js given its popularity in modern web application projects.

4.1 Front End Design

The initial design for the prototype was developed in tandem with the background research and requirements gathering. The design development took a semioparticipatory approach; in other words, preliminary features were designed beforehand based on the background research, then

surveyed LGBT+ individuals were used to validate and inform further development of those features. The features were described in the surveys as followed:

1. **Heatmap**: A visualization of any city/town describing "safe" and "neutral" zones based on the availability of resources in the area and user-submitted input. This would be in the form of a heatmap and would be publicly viewable (not requiring registration).

2. **User Map**: This feature would showcase an exhaustive list of LGBT+ resources for any given city/town. The User Map would not only list resources, but also display their locations on a map for visual clarity. This map/list combination would only show a registered user the available resources if they were within city/town limits; otherwise, access to this database would be barred.

3. **User Accounts**: User accounts as well as a user rating system would help validate resources in any area and provide any unique context to a city/town. This would encourage community development and participation and help ensure the validity of resources displayed in the application.

The design was built using Adobe XD, a prototyping software that allows designers to mock up the UI and UX features quickly without any actual programming needed. Upon accessing the web application, the user would interact with a landing page to direct them how to use the rest of the application. This is shown in Figure 4.1.

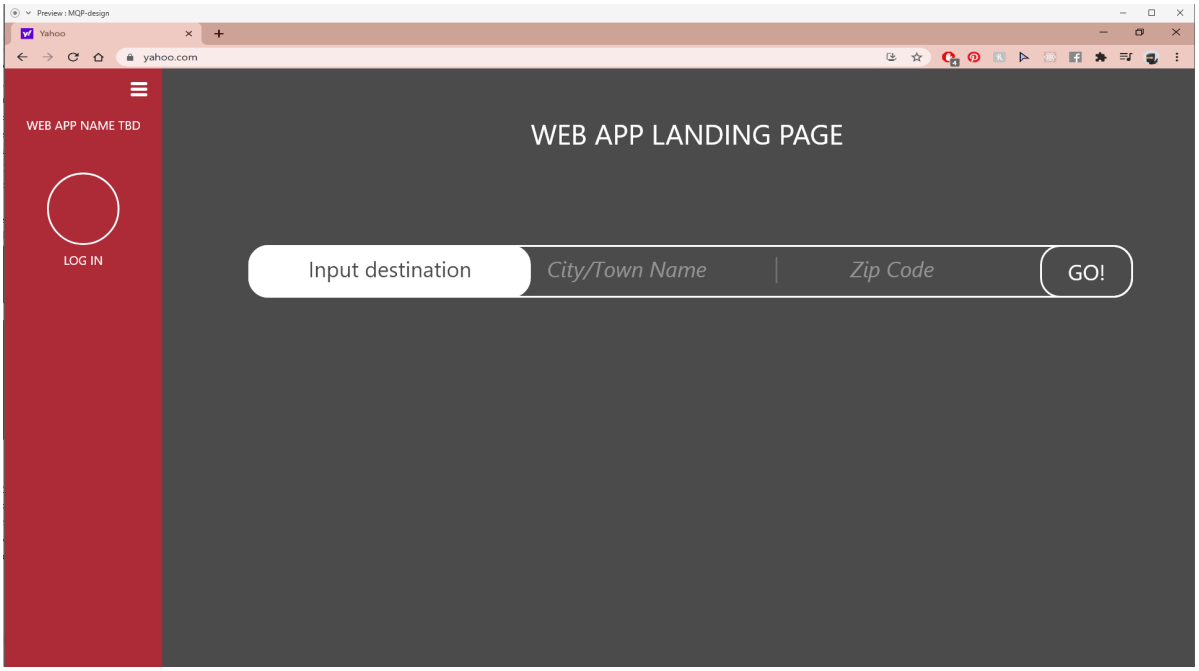

Figure 4.1: *Preliminary design for the landing page, developed using Adobe XD. The full prototype design is in Appendix B*

The Adobe XD prototype included a retractable navigation bar on the left-hand side. This was an aesthetic choice meant to simplify the web application's visible content and prevent focus from being drawn away from the main window.

Initially the landing page was designed to host a search bar that would be used to interact with the first feature: the heatmap. The heatmap feature would be queryable by a user-inputed location via the search bar. However, the search bar was discarded during the development process of the application as it was found to be an unnecessary abstraction. Later iterations of the design would have the heatmap feature displayed on the landing page itself.

4.1.1 Choosing a Map Framework

Originally, the heatmap was going to be built using Tableau. Tableau is a popular analytics platform that allows users to build dynamic, highly interactive data visualizations without the need for programming (i.e. it's not a data visualization framework library like d3.js). Tableau has support for a diverse set of visualizations, including map-related visualizations such as the heatmap. It also had integrative support for Javascript, meaning it is easy to integrate a Tableau visualization into a web application. However, there were many drawbacks to using Tableau: first, Tableau is a for-profit service that packages its features into separate tiers that one would have to pay for individually. While there is a student license available, it does not cover all of the tiers, and the services that the student license did cover required multiple downloads. Finally, integrating Tableau into the web application was not as smooth as previously thought. Using Tableau had certain trade-offs; by offering a streamlined, simplified method of designing visualizations, it made fine-tuning the visualizations difficult. Issues with maintaining Tableau dependencies led to the conclusion that Tableau was not a sustainable, fully editable solution to the heatmap feature.

OpenStreetMap API, Google Maps Platform, and MapboxGL were then considered as other options for the heatmap feature. The priorities were to (1) display a dataset on a map as a heatmap, (2) use a service or pricing tier that would not require payment and (3) use a service that was well documented online for ease of development. OpenStreetMap API is an open source map API where users can contribute mapping data. The application would not have been compatible with OpenStreetMap API because it was not desirable to contribute data to an open-source map and display it on a webpage. In addition, OpenStreetMap utilizes additional services for functionality beyond the basics of moving around a map that were not needed for the prototype. The Google Maps Platform allows for users to create fully customizable, interactive maps as well as utilize street view [33]. There is also an existing, well-documented heatmap visualization library in which users can input custom data sets. However, the team felt that Google Maps' pricing and plans would not be ideal for the application.

As shown in Figure 4.2, Google Maps offers $200 in credit every month to users. To display dynamic maps, the price would be $7 per 1000 requests, which would translate to about 28,500

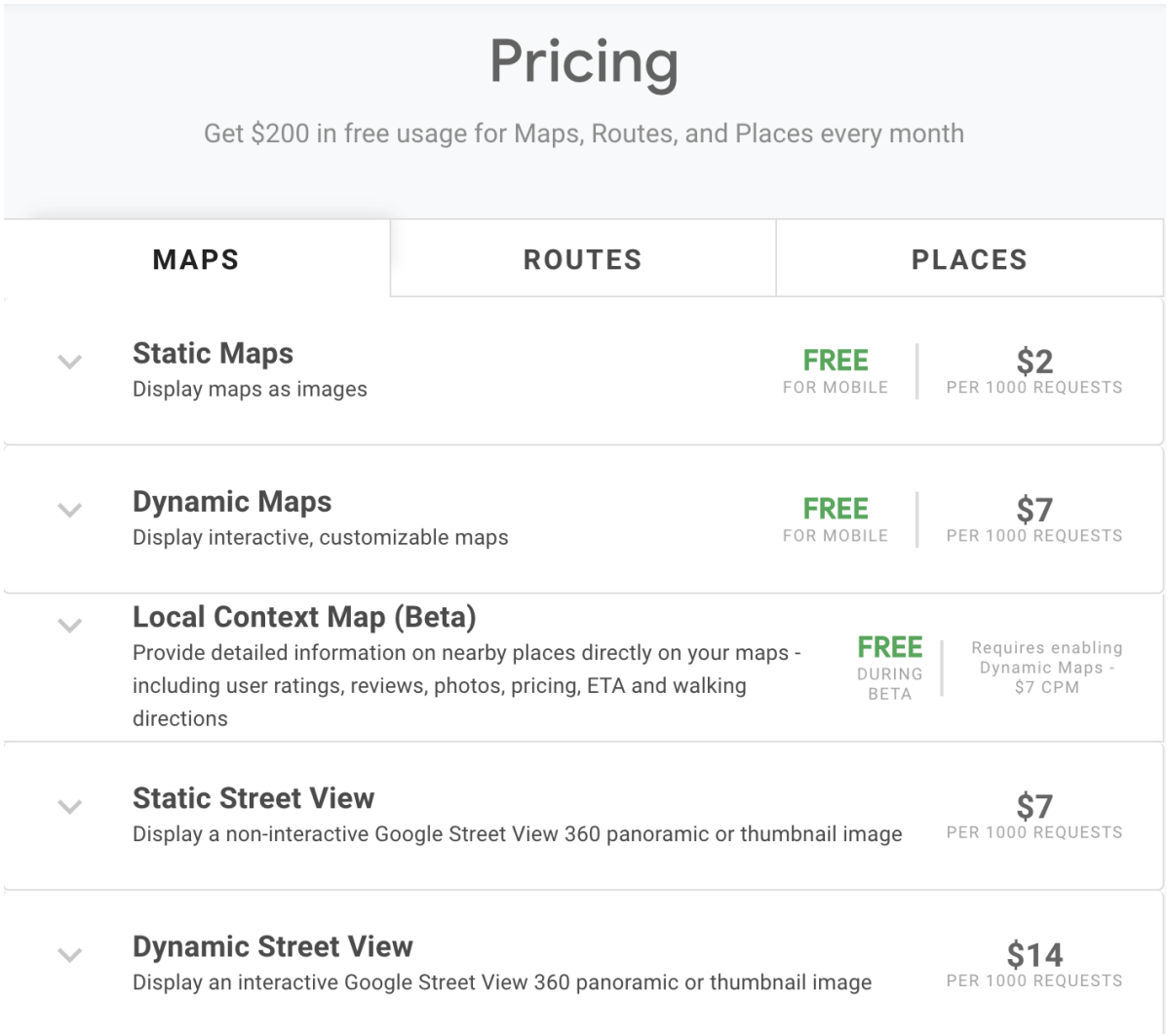

Figure 4.2: *Google Maps Platform's pricing.[5]*

requests per month for simply displaying the map. On the other hand, MapboxGL offered the same functionality the application required at a lower price. MapBoxGL also allows users to create fully customizable, interactive maps and has a heatmap API in which users can input their own datasets to display.

As shown in Figure 4.3, MapboxGL's free tier allows for users to make 50,000 requests per month, which is almost double Google Maps' free tier. Since the application was built with humanitarian groups in mind, the idea was to keep the application scalable while reducing the funds needed to maintain it. Therefore, using MapBoxGL was ideal for both the heatmap and user map.

Figure 4.3: *MapboxGL's pricing. [5]*

4.1.2 Heatmap and User Map Design Decisions

The background research underlined the serious issue of resource access inequity in the United States, so a feature was developed that would raise awareness on the topic as well as actively provide the community with a view on how well a city/town is doing in terms of resource availability. Doing so would also give humanitarian groups a way to quantify what and where the needs in the country are; in other words, by being able to judge a city based on the quality and quantity of LGBT+ resources available, advocates can push for the introduction of more resources in cities that are comparatively under-performing.

In using a heatmap, the visual data would be easiest to interpret at a glance and can convey the most amount of insights to a person without revealing actual address information. A user can simply input their desired location and see the concentration and availability of LGBT+ resources for that location. This functionality would act as a vehicle for a user to make their own informed determinations about the location, which supports the goal of democratizing access in the United States. The preliminary design for this feature can be shown in Figure 4.4.

Due to security concerns, some parts of the application were designed to be publicly viewable, while others were meant to be private. The heatmap was a public access visualization that anyone interested to see how cities and towns shaped up could view, denoting enough information to make conclusions about resource equity in that location while also not revealing the locations of those resources. The goal was to consolidate a region's available LGBT+ resources into one centralized platform. It was found that LGBT+ resources are rarely listed in full; finding resources meant individually searching up specific resource criteria into a search engine and hoping the query yields all possible resources fitting that criteria in the area. In the context of the university student audience, students were dependent on their institutions' LGBT+ outreach resources, if any, to inform them of available resources in the area. These lists were often not all-inclusive of the resources in the area.

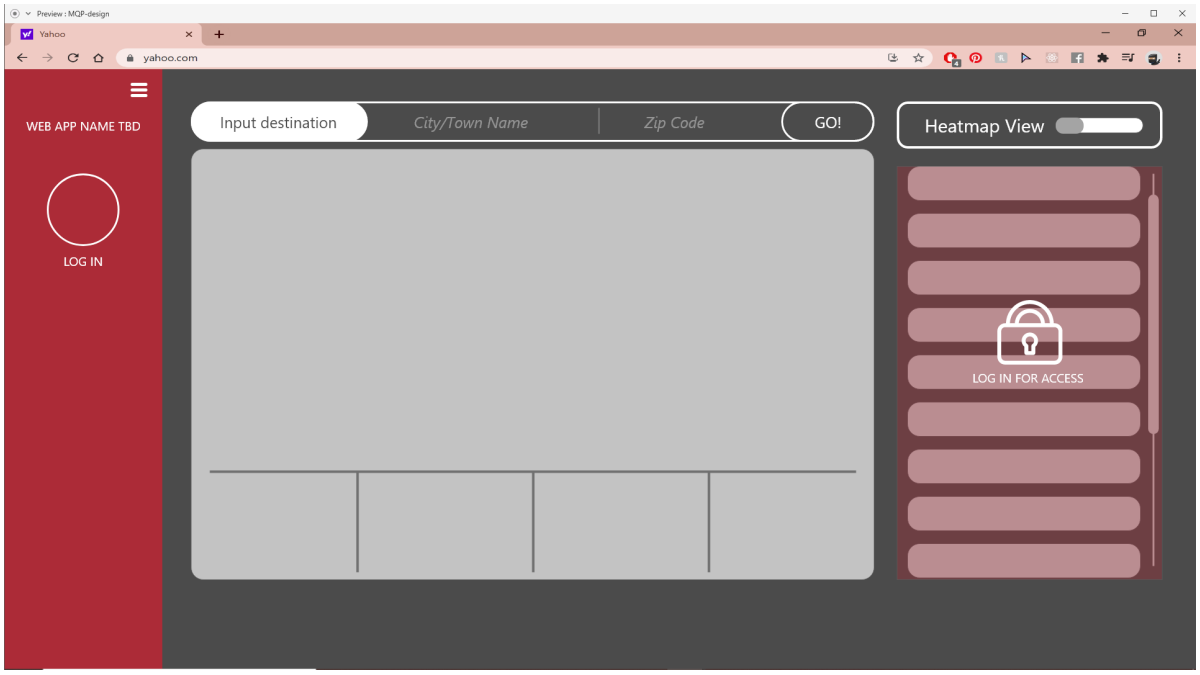

Figure 4.4: *Preliminary design for the heatmap function. The light-grey window would be where the heatmap resides.*

The user map feature was designed to only be accessible for users with accounts. The map would display markers showing the precise locations of resources in the area, pulling resource data from a database that held a curated list of resources for that particular location. The map would also display a list of resources and their locations to the side, in which each element was interactive and could display more information about the resource. This is evident in the preliminary design for this feature, shown in Figure 4.5.

Since the heatmap was intended to be implemented using MapboxGL, MapboxGL was also used for the user map for simplicity and standardization purposes.

The original design for the user map showcases a *Sort By* filter feature. The thought process behind this filter would be to allow users to sort through the resources by name, rating, and other fields. Later it was decided to not implement this feature in the prototype as it was a lower priority compared to the other features.

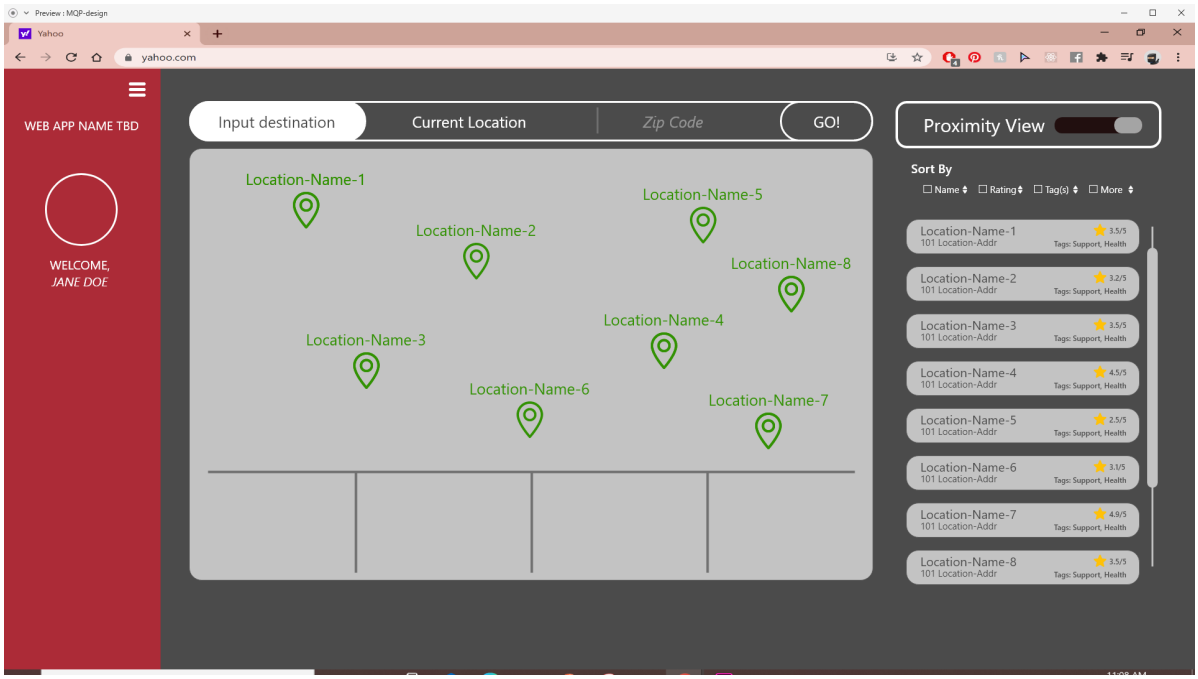

Figure 4.5: *Preliminary design for the user map function.*

4.1.3 User Accounts and Reviews Design Decisions

User accounts were a necessary addition to the application as it was important for cleared users to interact with their communities. The main way for registered users to interact with one another is with the user reviews feature. When designing user review capability, research supported the need for applications geared towards helping a marginalized population to allow that population to interact with one another (see section 2.7). However, it's important to balance and mediate this interaction.

The user accounts consist of a simple username and password combination. The username must be unique for the entire application, and both fields must conform to length standards. The username and password are used to identify a user during login and connect the user to a 2FA secret value. During registration, a secret value is associated with each user and embedded into the QR code. Users are asked to scan the QR code into the Google Authenticator application for iPhone and Android, which generates six-digit codes intermittently. In addition to providing a username and password during login, users must supply the current six-digit code, which is validated using the user's 2FA secret value (see section 5.3.1).

4.2 Back End Design

The typical web application architecture consists of a server, consisting of a series of GET and POST routes, and a database, which may be hosted on a different server. Firebase offers

developers a serverless architecture in which each part of a traditional web application backend is managed by a Firebase service in the cloud. The Firebase services relevant to the application are Firebase Hosting, Authentication, Cloud Functions, and Cloud Firestore.

Firebase Hosting is the Firebase equivalent of a server hosting webpages. The React.js application is built on developers' personal computers and then deployed to Firebase Hosting. After deployment, the new React.js build is immediately available for users to view and interact with in their browser. Firebase Hosting also automatically provides its own, self-managed SSL certificates, ensuring the application is always hosted via HTTPS.

Firebase Authentication couples closely with Firebase Hosting, as it manages active user sessions. After a user's account credentials are confirmed during login, the client receives a JWT, which is a signed token containing the account's UID. The JWT is then passed to Firebase Authentication, which deciphers the JWT and stores relevant information in the user's browser so that all parts of the frontend are aware that a user is signed in. This information is also sent with Firebase API calls, and can be used to allow or bar access to certain actions or pieces of data.

Firebase Cloud Functions are a means of executing server-side code, and take the place of traditional POST requests. The Cloud Functions are hosted as a series of distinct URLs and, like Firebase Hosting, are hosted via HTTPS. The application makes use of three Cloud Functions: account registration, account login, and review writing. When the application needs to make use of the functionality of the Cloud Functions, the React.js frontend calls the required Cloud Function using the Firebase API. Each Cloud Function receives two pieces of data from the Firebase API. The first data piece is any information that the frontend manually attached to the API call, such as account or review information. The second piece is a context object which Firebase automatically attaches to the call which allows the Cloud Function to determine if a user is signed in and, if so, who they are.

Lastly, Cloud Firestore functions as the database. Rather than a traditional database design of a table containing records, Cloud Firestore organizes data into collections of documents. Each document is hosted at a distinct HTTPS URL. Under normal circumstances these documents would be publicly available, as both the frontend and Cloud Functions are. However, Cloud Firestore allows developers to specify access rules for when and how users are allowed to read and write to collections or documents (see section 5.3.2).

4.3 Application Threat Modeling

As stated in the guidelines for humanitarian application development, security is the most important consideration when developing technology for vulnerable audiences. To understand how this application might be attacked, application threat modeling was performed using the STRIDE and DREAD methodologies. The STRIDE methodology seeks to identify where and how the application can be attacked using the application model developed in Figure 4.6, while the

DREAD methodology quantifies the likelihood of an attack for each scenario on a scale from 1-10, with 10 being the most likely, by rating each scenario in several categories and then taking the average score. From the STRIDE scenarios (see Tables 4.1 and 4.2) and DREAD ratings (see Table 4.3) it was possible to identify where, within each application component, security improvements could be made.

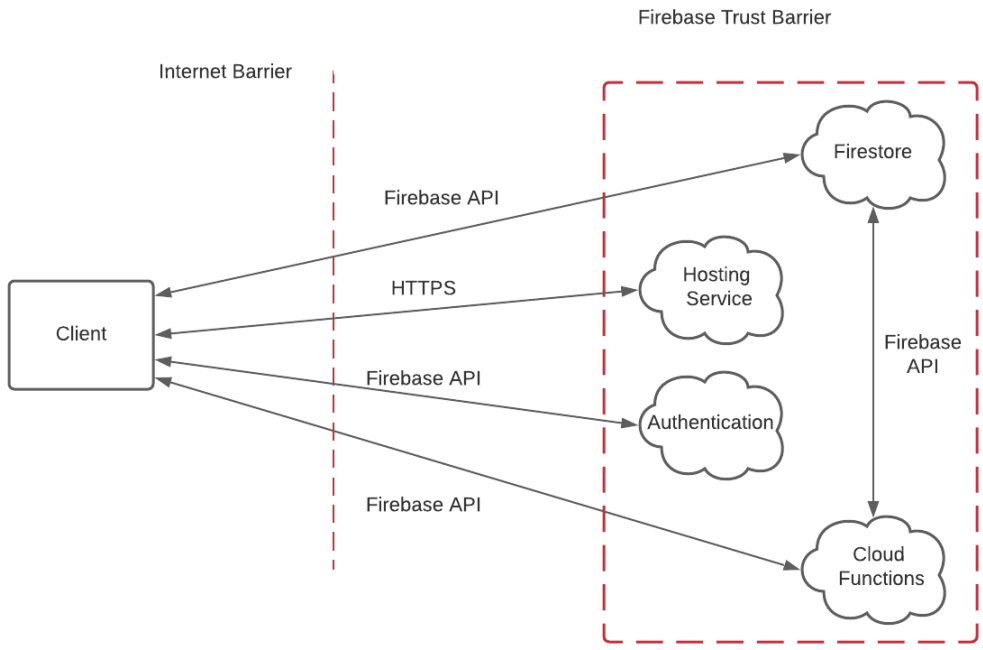

Figure 4.6: *A simplified model of the application system and the interactions between its components*

When performing the STRIDE analysis, scenarios were assessed using the interactions between system components in one direction; that is, the interactions heading outbound from the client are assessed independently of the incoming interactions. This approach to STRIDE offers the perspective of a single component being compromised, with normal application traffic still flowing. From the completed STRIDE model in Tables 4.1 and 4.2 two conclusions can be drawn:

1. All outbound interactions from the client carry a spoofing risk.

2. All inbound interactions to the client carry a tampering risk.

Each of the 16 scenarios from the STRIDE model was given a DREAD assessment based on the damage the attack would cause, how reproducible the attack would be, how easy it would be to perform the attack, how many users would be affected, and how easy the attack is to discover. Though not explicitly listed, each DREAD assessment took into consideration existing defenses, such as the native HTTPS support from Firebase or digital signatures [34].

ID	Location (From -> To)	Action	Category
1	Client -> Cloud Functions	Login	Spoofing
2			Information Disclosure
3		Writing Reviews	Spoofing
4			Tampering
5			Repudiation
6	Client -> Firestore	Querying map data	Spoofing
7			Escalation of Privilege
8	Client -> Hosting Services	Displaying components	Spoofing
9	Client -> Authentication	Logging in with JWT	Spoofing
10			Tampering/Denial of Service
11	Firestore -> Client	Returning map data	Tampering
12			Information Disclosure
13			Denial of Service
14	Cloud Functions -> Client	Returning JWT	Information Disclosure
15			Tampering
16	Hosting Services -> Client	Getting webpage	Tampering

Table 4.1: *The STRIDE model, showcasing which STRIDE categories apply to actions performed between different system components*

ID	Description
1	Attacker logs in as someone else by guessing password
2	Attacker obtains login information from network traffic
3	Attacker writes a review as someone else
4	Attacker intercepts and alters a user's review
5	Attacker tries to write malicious reviews anonymously
6	Attacker accesses Firebase pretending to be logged in
7	Attacker attempts to access all Firebase contents
8	Attacker attempts to access restricted components
9	Attacker authenticates with a valid JWT
10	Attacker alters user's JWT to prevent login
11	Attacker intercepts and alters heatmap data
12	Attacker intercepts data in transit
13	Attacker floods Firestore with requests for heatmap data
14	Attacker intercepts JWT
15	Attacker alters JWT
16	Attacker alters webpage data in transit

Table 4.2: *Descriptions of each attack evaluated by STRIDE-DREAD*

Of note from the DREAD model in Table 4.3 is the average rating of client-side spoofing attacks and Firebase-side tampering. Spoofing attacks performed during outbound client interactions have an average rating of 4.28 while inbound tampering attacks average 3.6. Despite there being more opportunities for these attacks to occur, when considering the average of all non-spoofing

outbound and non-tampering inbound attacks, which registers at 3.7, spoofing and tampering pose no more of a threat to the application than other methods, and thus specific defenses can be implemented on a per-scenario basis as opposed to general STRIDE-category defenses.

ID	D	R	E	A	D	Rating
1	2	2	10	3	10	5.4
2	4	1	3	3	3	2.8
3	5	7.5	7	3	7	5.9
4	5	1	3	5	3	3.4
5	5	3	3	5	3	3.8
6	2	3	2	5	1	2.6
7	7	8	2	10	1	5.6
8	2	10	10	1	8	6.2
9	2	1	2	1	1	1.4
10	3	1	3	3	3	2.6
11	6	1	3	3	3	3.2
12	6	1	3	3	3	3.2
13	10	3	2	10	3	5.6
14	5	1	3	3	3	3
15	2	7.5	5	3	5	4.5
16	6	1	3	3	3	3.2

Table 4.3: *The DREAD model, rating each STRIDE scenario for damage, reproducibility, exploitability, affected users, and discoverability*

Chapter 5

Application Prototyping: Development

The application development process was met with a lot of challenges and obstacles, from the development of the map visualizations used in the application to the unique security measures taken to secure the project. Due to the emphasis on getting the prototype as production-ready as possible, many considerations were given to the security of the application as well as the user experience elements of the features. To support this, the team developed a strict workflow to ensure proper attention was given to all parts of the prototype.

5.1 Development Practices

The team met during the research phase biweekly to discuss research needs, gathered requirements and fine-tuned the project goals. During the development phase, the team transitioned to the Scrum method and used Jira to track tasks and project development. One week sprints were used, holding a major sprint planning meeting at the beginning of each sprint and ending it with a sprint retrospective. The sprint retrospective gave the team the opportunity to communicate successes and failures of the past week and determine resulting goals for the next. A full list of the team's contributions can be found in Figure 5.1.

The team had a system of scheduling work sessions during the week, which ran outside of the biweekly major team meetings. These work sessions were between three and six hours long, which was spent either pair programming to find a major solution to a problem or developing independently of one another. This system allowed the team to mitigate merge conflicts and avoid redundant work.

Team Contributions	
1. Background Research	Veronica, Sarah
2. Methods Development	Nathan
3. Application Security	Nathan
4. Map Visualizations	Sarah
5. Primary Backend Developer	Nathan
6. Primary Frontend Developers	Sarah, Nathan
7. Secondary Frontend Developers	Veronica, Daniel
8. Fieldwork and Outreach	All
9. UI Design	Veronica, Sarah
10. Database Management	Daniel
11. Primary Paper Editor	Veronica
12. Secondary Paper Editors	All

Table 5.1: *Team contributions to the project*

5.2 Developing the Prototype

The proof-of-concept prototype was successfully created using the guidelines developed from the research and fieldwork. The prototype allows users to visualize resources in select towns and cities within Massachusetts, both in general (the heatmap visualization) and in detail (the user map feature). Depending on their registration, users can also contribute to the community by validating and reviewing resources, which is helpful in mitigating potential unsatisfactory or misleading resources in the database.

5.2.1 Utilizing Maps to Visualize LGBT+ Resources

As previously stated, MapboxGL was utilized for both the heatmap (see Figure 5.1) and user map (see Figure 5.4) visualizations. Since the frontend implementation uses React, the Javascript API of MapboxGL was used to create both maps.

The heatmap can be accessed by any user regardless of their logged in status using the path, */heatmap*. Development began by creating a basic MapboxGL map implementation that renders a map and allows a user to navigate using scroll and zoom. The resource data is passed into the MapboxGL API in GeoJSON format which is a standard format for representing geographical features. For the heatmap, the GeoJSON only contains the coordinates of the resources in the database as shown in Figure 5.2. There is no other information about a resource displayed to prevent a malicious user from abusing the resource.

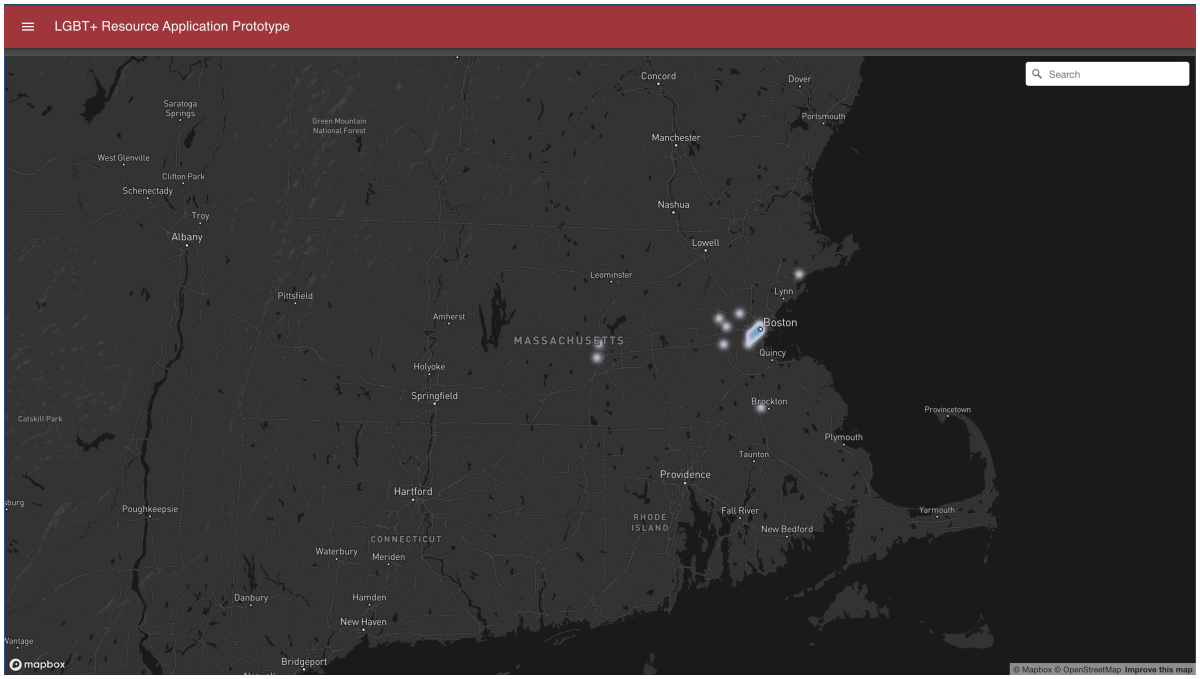

Figure 5.1: *The heatmap displayed in the prototype. Users cannot view resource details in this implementation.*

```
{
    "type": "FeatureCollection",
    "features": [
        {
            "type": "Feature",
            "properties": {"name": "A Location"},
            "geometry": {
                "type": "Point",
                "coordinates": [
                    0,
                    0
                ]
            }
        },
    ]
}
```

Figure 5.2: *The GeoJSON structure used in the heatmap implementation.*

In addition, a Geocoder feature was added to the map through the MapboxGL API. A Geocoder matches addresses to specific geographical locations. As shown in Figure 5.3 a user can input a location and view the spread of resources around that area. To comply with the security rules, a user will still not be able to view the location or details of the resources. The heatmap simply provides a visualization of the spread of LGBT+ resources based on the data set.

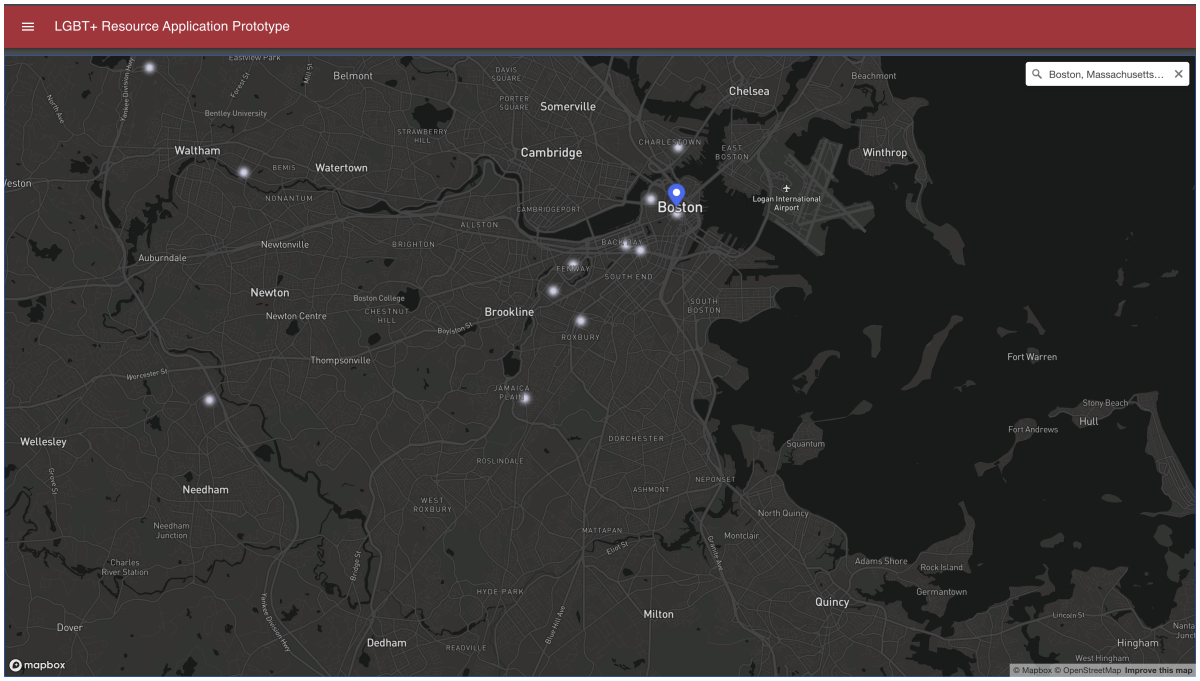

Figure 5.3: *An potential user may utilize the Geocoder to search for Boston, Massachusetts.*

Although MapboxGL easeed the development process of the maps, there was still a steep learning curve for the team. For one, not many of the team members had extensive experience with React. An issue was encountered numerous times with the rendering of the map. At times the map would throw an error and not load at all, or the npm libraries being used had conflicting documentation. The team then spent time exploring React functional components, hooks, and rendering concepts. Npm packages were switched to use 'mapbox-gl' and '@mapbox/mapbox-gl-geocoder' which were the official packages provided by MapboxGL for React implementations. After making these changes, the map began rendering and resource data was able to be inputted for display.

To build the user map (see Figure 5.4) , the team focused on three main features: a geolocator, map markers, and a list of resources. The basic MapboxGL map implementation was built with the Geocoder, similar to the heatmap implementation. However, the map style was changed from *dark* to *streets* to make the markers more visible for users. A geolocator was also added to the map using the MapboxGL API. The geolocator centers the map on the user's precise location, assuming they give the application permission to do so. A user can then scroll and zoom to view resources near them.

To display the full user map it was necessary to (1) pull resource data from Firebase, (2) format the data into a GeoJSON, and (3) display the resources on the map as map markers. A similar workflow was used to build the list of resources. To pull the resource data, the Firebase API was used to first check if a user was logged in and authenticated. If so, the application then accesses the data stored in a Firebase collection. The data is then formatted and stored as a

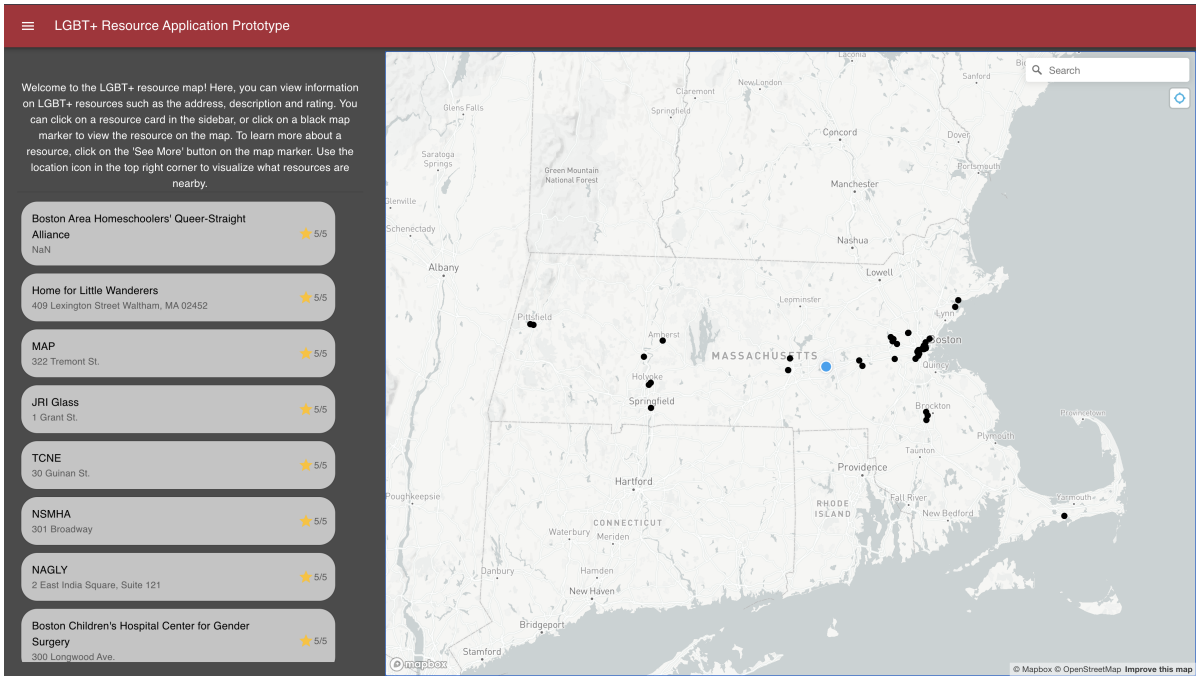

Figure 5.4: *Resources are displayed on a map as well as a sidebar on the user map page. The black dots represent clickable markers for the resources, and the blue dot represents the user's current location.*

GeoJSON. Unlike the GeoJSON used in heatmaps, this GeoJSON contains more information about the resource in the "properties" field as shown in Figure 5.4. The data is then passed to the MapboxGL API and added to the map as a map markers layer.

```
let tempInfo = {
  "type": "Feature",
  "properties": {
    "uid": doc.id,
    "Address": thisData.Address,
    "City": thisData.City,
    "Description": thisData.Description,
    "Email": thisData.Email,
    "Name": thisData.Name,
    "Phone": thisData.Phone,
    "Website": thisData.Website
  },
  "geometry": {
    "type": "Point",
    "coordinates": [
      thisData.Longitude,
      thisData.Latitude
    ]
  }
}
data.features.push(tempInfo);
})
```

Figure 5.5: *A representation of the resource GeoJSON structure.*

One particular challenge with the maps was addressing the data flow. The map would attempt

to render before the application was done collecting and formatting the data from Firebase, resulting in an error. A combination of React.js state hooks and useEffect() was used to solve this. React.js state hooks allow for the use of states inside a functional component. Keeping track of the state helps determine what data has and has not been updated and what is currently being rendered. The useEffect() hook performs side effects in functional components. In this case, the map needed to render after the data collection and formatting had finished. The useEffect() function was used to render the map after the states of *user*, which determines whether a user is logged in or not, and *dbData*, which determines if the data has been loaded in, have been updated. Once both states are updated, the map can then display the data for the user to access.

A similar data collection and displaying workflow is used for the list of resources displayed in a sidebar on the page. After the data has been collected from Firebase, it is formatted into clickable dialogues that are then put in a scrollable list. If either a marker or a resource on the sidebar is clicked, a popup appears on the location in the map. The popup displays the resource name, address and contains a button that leads to the resource page, displaying more information.

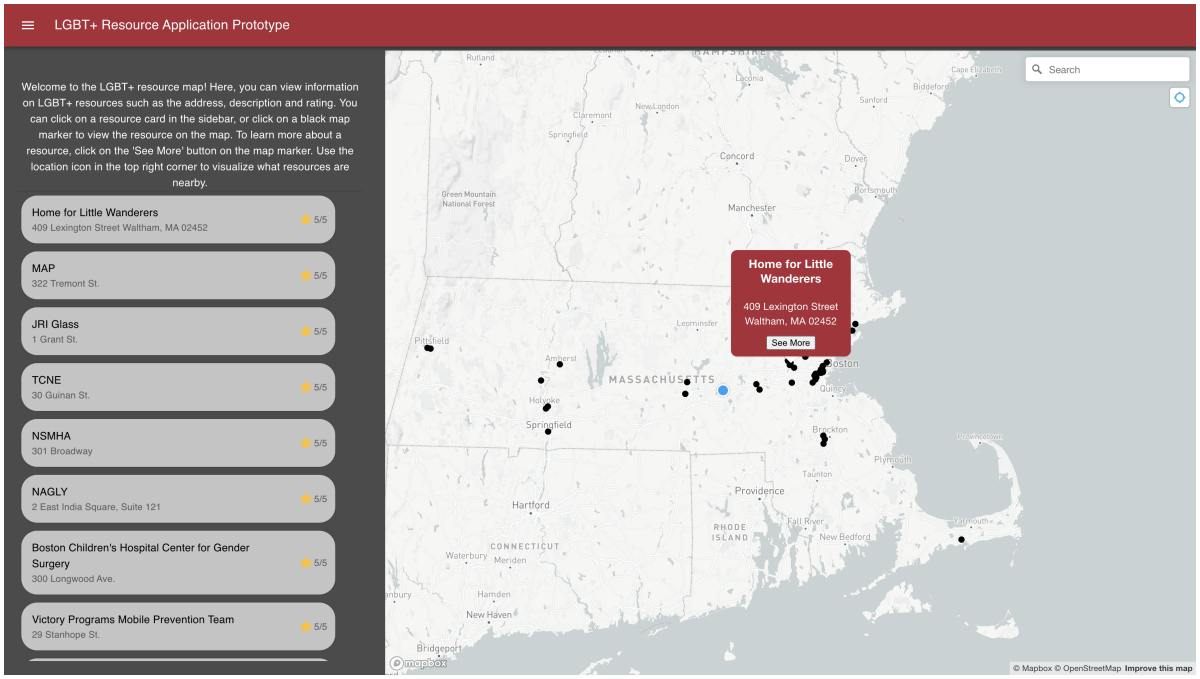

Figure 5.6: *The marker appears on the map at the location of the resource if a user clicks on a resource in the list or on the map.*

5.2.2 Allowing Users to Review Resources

As found through the HCI research, increasing the amount of information users can exchange encourages higher community participation. For the app, signed in users were allowed to rate

and review resources. Resource reviews contain a short (300 characters) optional description and a required numerical rating of the resource's quality using 1-5 "stars," where more "stars" indicate higher quality. Users are also given an option to display their username as "Anonymous" for the review.

Resource reviews are their own page, separate from the maps. The ID of the resource being reviewed is a parameter of the page's URL. When submitting a review, the URL parameter is associated with the review content and is sent to the review cloud function, which sanitizes input and rejects malformed or profane reviews.

5.3 Securing the Application

Numerous security measures have been implemented throughout the application to combat a variety of attack channels. Many of these measures also serve to directly rectify STRIDE scenarios developed in section 4.3.

5.3.1 Protecting User Accounts

For the application, several layers of security have been implemented to keep user data safe. The first line of defense is the user's password, which must be 8-64 characters long. Though it may seem counterintuitive to not enforce password complexity and composition requirements, users have been shown to ignore password policies in exchange for weaker, more memorable passwords [35]. To encourage users to voluntarily create stronger passwords a simple password strength meter was implemented, as seen in Figure 5.7. Users who are exposed to password strength meters create passwords with 30-40% higher entropy than users who are not exposed [36]. To actually measure the password strength the open source ZXCVBN Node.js module, created by Dropbox, was used. ZXCVBN scores password strength based upon pattern recognition, including sequences and repetitions, numerical letter substitution (ex. hello -> h3ll0), and comparisons with 30,000 common passwords, names, English words, and pop culture references [37]. The ZXCVBN module is also the reason why there is a maximum length for passwords, as its performance begins to drop when using larger passwords.

The second layer of user data protection comes in the form of 2FA during login. During account registration users are asked to use the Google Authenticator app, or other OAuth app, to scan a unique QR code. This QR codes contains an embedded secret value, and once scanned the authenticator application will use the embedded value to generate a new six-digit value every 30 seconds. During login, users must enter their current six-digit 2FA value along with their username and password. With the implementation of 2FA, even if an attacker is able to guess a user's password they will be unable to log into the account without the code on the user's authenticator.

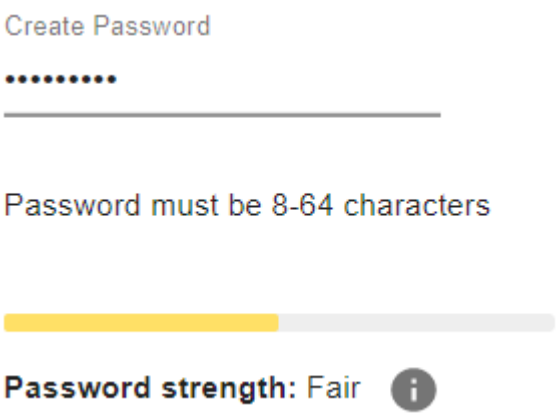

Figure 5.7: *The password '115599cba' scored on the strength meter using ZXCVBN*

The last layer of security is the cryptographic hashing of the user's password within the database. During account registration, the open source BCrypt Node.js module is utilized to hash user passwords. By storing the password hash instead of the password itself, even if the database contents are leaked an attacker will not be able to immediately obtain user passwords. Since hash functions are one way, there is no way for the attacker to reverse engineer the user's password from its hash, and thus they will still need to guess at the password as they would during normal login [38]. Utilizing the BCrypt module also has the advantages of handling the use of password salts automatically and easily changing the balance of performance versus security.

5.3.2 Securing Cloud Firestore

In addition to protecting individual pieces of user data, security measures have been implemented to protect the database, Firebase's Cloud Firestore, as a whole. As a passive layer of security, Firebase encrypts all Firestore content at rest, meaning a breach in the Firebase servers does not necessarily mean a breach of Firestore data. In addition, during the user login process, once the backend has confirmed that the user can be successfully logged in it sends a JWT to the client's browser. A JWT is a means of transmitting cryptographically signed data between two parties. In the case of this application, JWT contains the user's UID. The client's browser then uses the JWT to authenticate with Firebase.

By design, Firestore is open to the public. Anyone who knows its URL can query for data. To fix the glaring security issues that arise from this design, rules for accessing data can be specified, shown in Figure 5.8

```
rules_version = '2';
service cloud.firestore {
  match /databases/{database}/documents {
    function signedIn(){
      return request.auth != null;
    }
    match /users/{userID} {
      allow read: if signedIn() && request.auth.uid == userID;
      allow write: if false;
    }
    match /resources/{resID} {
      allow read: if signedIn();
      allow write: if false;
    }
    match /reviews/{revID} {
      allow read: if signedIn();
      allow write: if false;
    }
    match /reviewAuthors/{revAuthID} {
      allow read, write: if false;
    }
    match /userOTP/{uotpID} {
      allow read, write: if false;
    }
  }
}
```

Figure 5.8: *Firestore security rules dictating access to different data collections*

When a user queries for data, Firestore determines if the request should be allowed to complete based upon these rules. It is here that the user's JWT authentication comes into play. Because Firestore queries are made through the Firebase API, Firebase attaches the users authentication object to every query. Within the Firestore security rules it is easy to check if there is a signed in user by seeing if the incoming query has a value for its *auth* field. For resources and reviews, users may only retrieve data if they are signed in. And for users' account data, not only does the user need to be signed in, but the UID contained in the JWT the user authenticated themselves with must match the UID of the data being read; that is, a user may only retrieve data that they own.

These security rules not only control read access, but write access as well. In Figure 5.8, all write conditions are set to *false*, meaning that under no circumstances may a user write anything to the database. Though this may make it seem like the database will never be able to receive new data, all these security rules do is dictate how clients can interact with the database. When a user wishes to add new data, such as registering a new account or writing a review, the request is passed to the respective Firebase Cloud Function, which checks whether data conforms to formatting and content standards, and then is loaded into the database. The Firebase Cloud Functions run at a higher privilege level than the clients, and are granted write access to the database.

5.3.3 Private React.js Routes

As part of the application design, the heatmap is publicly visible while the user map is only visible to signed in users. To achieve this, a React.js component was created that conditionally displays other components depending on whether a user is signed in. During the initial rendering of the protected component an internal state is set to null. Once the component is mounted in the webpage, a Firebase Authentication State listener is created. Upon creation, and as the signed in status changes, the listener determines whether a user is signed in, then sets the internal state to true if a user is found or false otherwise. This internal state change triggers a re-render of the React.js component, and, upon reading the new value of the internal state, will either render a protected component or will redirect to the home page. The setting of the internal state is depicted in Figure 5.9.

```
componentDidMount() {
    firebase.auth().onAuthStateChanged(user => {
        let res = false;
        if (user) {
            res = true;
        } else {
            res = false;
        }
        this.setState({ userStatus: res }, () => {
            //this output forces a state update
            console.log(this.state);
        });
    })
}
```

Figure 5.9: *Code snippet for altering the user state based on signed in status*

5.3.4 Combatting Malicious Reviews

When leaving a review for a resource, users must supply a short description about their experience, a numerical rating of the resource's quality, and must specify whether they are leaving the review anonymously. An issue arises where users could leave an anonymous review with hostile language in an attempt to antagonize the application's legitimate users. The reviews employ several countermeasures to discourage such behavior.

The first roadblock malicious reviews hit are description requirements. Review descriptions are limited to 300 characters to limit storage requirements in the database and are screened for profanity. Any profane or overly-long description is denied. Though the profanity filter counters many slurs, swears, and other inappropriate words, it is not a perfect system.

The second countermeasure does not actively block malicious reviews. Instead, the review system takes advantage of the same authentication object created by the JWT described in section 5.3.2, which is sent automatically when calling the review cloud function. The review cloud function associates a user with the review they wrote regardless of whether the user chose to write the review anonymously. For every review added to the database, a second entry is also added that no client may ever read that associates a UID with a RID. Should a malicious review be brought to the attention of application moderators, the UID-RID association can be accessed to determine the author, and then take action against them accordingly.

CHAPTER 6

PROTOTYPE EVALUATION

In order to evaluate how user-friendly and beneficial the prototype application was to the target audience, a user study was performed utilizing the *think aloud* method with five user participants. The think aloud method involves observing a user as they go through a defined list of tasks. As the user performs these tasks, they are encouraged to vocalize their thoughts about elements such as the design, usability of the application as well as any specific features. The study was performed on five students from universities in Massachusetts, as they most closely represented the target audience for the prototype application.

The evaluation was performed through a Qualtrics survey. Users were instructed to perform seven different tasks in which they interacted with the application and its features. These tasks are listed in Table 6.1. As the user performed each task, they were prompted to answer guided questions describing what they see on the page, information gained and any opinions on the features. These guided questions are to ensure the user does not stray too far from the task. The full Qualtrics survey can be found in Appendix C.

Prototype Evaluation Tasks	
1	Navigate to the landing page and describe in detail what you see. You may interact with the side navigation bar for this task.
2	Take 2-5 minutes to explore the application on your own and note down your experiences here.
3	Navigate to the heatmap view. As of now, the available locations for you to observe are the greater Boston and Boston area. What is your initial impression of this page?
4	Register an account with the application.
5	Sign into the application with your new credentials.
6	Navigate to the user map view.
7	Click on a location and place a review.

Table 6.1: *Users performing the evaluation were instructed to perform seven tasks on the application.*

6.1 Prototype Evaluation Results

Overall, users felt that the prototype application would be a helpful resource for the LGBT+ community and its allies and was a good start at tackling the issue of resource inequity in the United States. However, many emphasized that there was room for improvement, especially in regards to the registration and account authentication process and the implementation of certain features.

The evaluation first prompts users to explore the application, namely the landing page, on their own and gather as many insights about the application as possible without actually creating an account and interacting with the features. When evaluating the UI of the application, users were able to point out most of the main features as well as identify the major interaction points on the application (i.e. that they would have to register an account to access a lot of the functionality, they were working with map visualizations, etc.). Users were able to successfully navigate the sidebar, the different views located on the sidebar, and the heatmap feature. All the users correctly identified the heatmap as one of the most important feature for the application; however, it is worth noting that none of the early responses (i.e., before the users were prompted to register and login) mention the user map feature despite text on both the landing page and the About the Project page discussing the main features of the application. This is likely due to the user map feature only being accessible through an account with the application; only the heatmap is available in the public view.

When evaluating the heatmap feature, users were generally able to navigate the visualization as well as understand how to use it. As one user commented, "[the] heatmap was very easy to navigate and it ran smoothly." Another user said "[it was] just like using any other map on the internet, so it was pretty easy." Users were also able to identify what the purpose of the

heatmap feature was, with responses varying from "location density" to "the street names and general location on the street of several LGBT+ safe spaces". A few noted that there were a lot of resources in Boston, and that of the surveyed towns/cities in Massachusetts, Boston had the most available. When prompted to input specific locations (within the database) to the heatmap, users were generally able to visualize those locations on the map, with the exception of one user who inputted "TCNE" into the search bar expecting the Boston location and instead receiving "Tyne and Wear" in England, UK. This has been noted as an error with the library's geolocation services and not on the part of the application.

A few users questioned the purpose of the heatmap feature. They felt that simply viewing the distribution of resources may not be too helpful without any other information on the resource. Once they navigated to the user map, they felt more satisfied with the map features presented there. In addition, the team intended the heatmap to be utilized by humanitarian workers or advocates to view LGBT+ resource disparaties across different regions. Therefore, it is understandable that a common user looking to find resources may not find it as helpful.

The next few tasks prompt the users to register an account and attempt to access the closed features with the application (the user map feature and reviews). The majority of users were able to successfully register an account, but opinions were split on how easy it was to do so. Four out of the six responses commented that it was easy to register an account. Of the two dissenters, one user commented that "[it was] not easy. Registering an account should be immediately proceeded by logging into the new account. It is not at all clear that you are supposed to log in using the code generated by the QR code in a separate task. Of the six responses, some felt that the modal/pop-up buttons for the registration overlay were a little unresponsive. The biggest point of contention for most users when signing in was that the 2FA process was not very intuitive; most did not realize that a secondary application was needed for 2FA. Of all the tasks, this one required the most guidance. However, most of the users were able to successfully register an account and sign in, with one commenting that the process was "pretty seamless, I like that it takes me straight to the heatmap."

The user map received mainly positive reviews, with one commenting that they found this view "... pretty intuitive and responsive." Users liked that there was "much more information" available for this view, with some commenting that they doubted the need for the heatmap with the user map in existence. All of the users were able to correctly identify the information one can learn with the user map: the resources and their respective details, where they were on the map, etc.

Reactions to the reviews were relatively similar; users were generally able to place a review, with some finding it took an extra second to locate the "Leave a Review" button. One user commented, "I think this is helpful to see if other people have been here." Another user thought it was similar to Google or Yelp reviews and found the comments mixed with the star ratings to be "easy to understand and helpful." The only points of contention with the reviews were over the

graphics, such as a need for more contrast in the UI elements describing the review page. Other than that, the functionality of the reviews was mostly viewed positively.

Although the surveyed users had a generally positive outlook with the app, almost all the users experienced issues with the login process. Some users were confused about the process to set up 2FA while others experienced issues with the QR code being stretched out on the display. An important insight with the surveys was discovering that the registration overlay experienced stretching difficulties when accessing the application on the Safari browser. One user's workaround was "[to take] a screenshot of the code and stretching it using third party software, [which was] not exactly user friendly." In addition, one user pointed out that if a potential user did not have a smartphone and an authentication app, they would be unable to utilize the application, therefore creating an unexpected barrier. There were also understandable concerns with some of the UI elements, such as making the review form have higher contrast in colors. The evaluation concluded that the prototype application was a good start towards creating an application for visualizing LGBT+ resources, but it still required further development and review to be put into production.

Chapter 7

Conclusion

The goal of this project was to provide a knowledge base for humanitarian application development and use the resulting framework to develop a prototype for LGBT+ advocacy purposes. LGBT+ advocacy was chosen because of its unique domain problems; the LGBT+ community is multifaceted and demonstrates a lot of the unique identity issues that modern application development frameworks overlook. The prototype is designed to help address the issue of resource access inequity present in the United States, as well as to provide a solution to this issue by developing a centralized database of resources for a given town or city. Many challenges were encountered during this development, from the interference of the COVID-19 Pandemic to software curve balls thrown into the mix.

7.1 Project Outcomes

Over the course of the work, our team successfully navigated challenges with the pandemic as well as the complexity of the project. These successes include:

- Consolidated a body of research from multiple disciplines to appeal to both humanitarian workers and technologists alike
- Gathered relevant opinions and perspectives from members and allies of the LGBT+ community to inform the prototype design as well as support the research findings
- Created and evaluated a modern web application using React.js, Firebase, and MapBoxGL for those in the LGBT+ community and their advocates to visualize access disparities in the country as well as gain their own access to a secure database of what's available to them.

Humanitarian application development is crucial to future advocacy efforts. As the internet grows and becomes more accessible to larger swaths of the world's population, the idea of helping people all over the planet is quickly becoming a more attainable goal. Technology efforts by humanitarian groups and social justice advocates must be conducted carefully due to the multifaceted complexity of the vulnerable populations at hand. Our hope is that this work will help technologists and advocates alike find a mutual ground to arrive on and begin work on future humanitarian technology projects.

7.2 Future Considerations

While a working prototype was developed for the humanitarian application idea, it is hoped that one day an iteration of the prototype can reach production level and be used to directly benefit the LGBT+ community. As such, several key areas of improvement have been identified.

7.2.1 Prototype Specific Suggestions

The database the prototype has in place is the bare minimum required for the application to function. To improve upon it, two steps can be taken. The first step towards improvement is the introduction of user account roles. If users could be distinguished as verified review writers, admins, or other roles, they could be granted certain database access that would bypass the Cloud Functions. Removing the middleware from writing to the database and allowing trusted clients to write improves the app's performance. A change to role-based database access also encourages community participation and ties into the second means of improving the database: adding new resources.

The prototype has no means of adding new resources. Allowing trusted users to suggest new resources has the benefits of removing the burden of finding resources from the developers and compensating for LGBT+ resources that were missed because they did not apply to the developers' identities. The inclusion of community-provided resources also coincides with the guidelines for humanitarian application development, which require participatory design and intersectional inclusivity.

Based on the prototype evaluation results, there are two major additional suggestions: (1) it would be helpful for another review of the UI design. Although the team focused on keeping the design as simple and functional as possible, users still ran into a couple of design issues that prevented them from having a seamless experience. Adding more descriptions to the different features and changing how reviews are displayed would greatly improve the design. (2) Another suggestion is to either make 2FA optional or provide more instructions on how to utilize it. Most of the users experienced issues with the 2FA setup, mainly because it is still a relatively new feature for the common internet user and they were unaware of the setup process.

7.2.2 Security Suggestions

Security improvements for this application mainly surround aspects of user accounts. The current user account set up consists of a profile, consisting of a username and password, residing in the *users* collection in Firestore and a 2FA secret value held in the completely private *userOTP* collection. Future iterations would benefit from the inclusion of an email address, both as a means of limiting spam accounts and for password reset purposes. Email addresses can also be used as a replacement for the 2FA system that is currently utilized, where randomly generated six-digit codes are emailed to users rather than gathered through a third party application

The current user account implementation also makes no mention of inactive user accounts. If users fail to sign into an account after some long period of time their account should be set to a temporary state of inactivity (where reactivation is confirmed through email) or deleted. Such a practice not only has the benefit of reducing the storage load on Firestore, but also, should there be a data breach of user information, then any user who reuses usernames and passwords across different websites will not have any of their other accounts' login information revealed [39].

Finally, users should be able to completely delete their account and log out of all active sessions. Deleting an account mitigates the risk of reused usernames and passwords from appearing in data leaks, as mentioned previously. Account deletion also completely severs the ties between the user and the application should the user be in a hostile environment. The use of Firebase Authentication for managing user sessions comes with the benefit of being able to invalidate refresh tokens based on the associated UID. Invalidating all currently-issued tokens for a user forces that user to reauthenticate to continue. Such a feature becomes useful when users access the application from multiple shared devices.

For non-account-specific security improvements, the application would benefit from a review moderation system. As part of the guidelines for humanitarian application development, a commitment to community mediation is necessary to ensure the success of the application Community mediation in the context of the application is the careful monitoring of reviews. Since the application caters to a historically-persecuted community there is a high likelihood of malicious users writing inappropriate or hostile reviews for resources using legitimate accounts. Although there is a system implemented to trace review authorship regardless of anonymous status, no system exists for the community to flag reviews for evaluation.

Appendices

Appendix A: Usability Surveys

We are a student project team from Worcester Polytechnic Institute (Worcester, MA) developing a web app prototype that would: (1) provide LGBT+ identifying users, particularly students studying in new towns/cities, with a centralized database of LGBT+ resources in their current locations and (2) provide advocacy groups (and other related parties) with a visualization on LGBT+ related resource availability across the United States. Our project goal is to help democratize access to LGBT+ resources and information in the United States, as well as raise awareness on issues surrounding unequal access that affect countless LGBT+ identifying individuals across the country.

We define resources as: LGBT+ friendly establishments, shelters, community centers, activist organizations and more.

Your participation in this survey is completely voluntary and you may withdraw at any time. Your answers will remain anonymous; no names or identifying information will appear on the questionnaires or in any of the project reports or publications. Our project team will use this information to inform our application design as well as add to our research. Thank you for participating!

Age:

- ○ < 18
- ○ 18 - 20
- ○ 21-30
- ○ 31-40
- ○ 41-50
- ○ 51-64
- ○ 65+

Figure 1: *Survey Page 1*

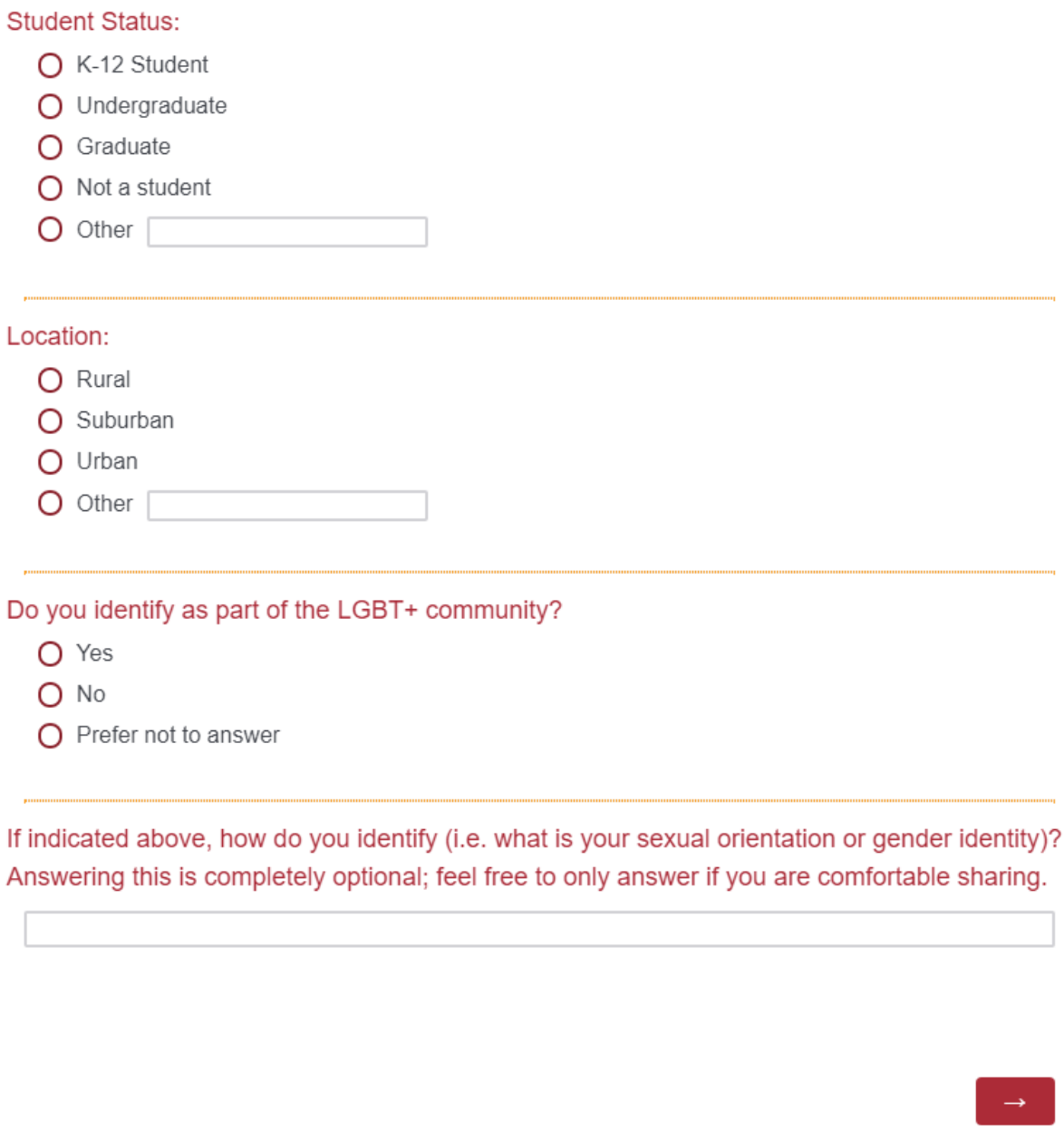

Figure 2: *Survey Page 2*

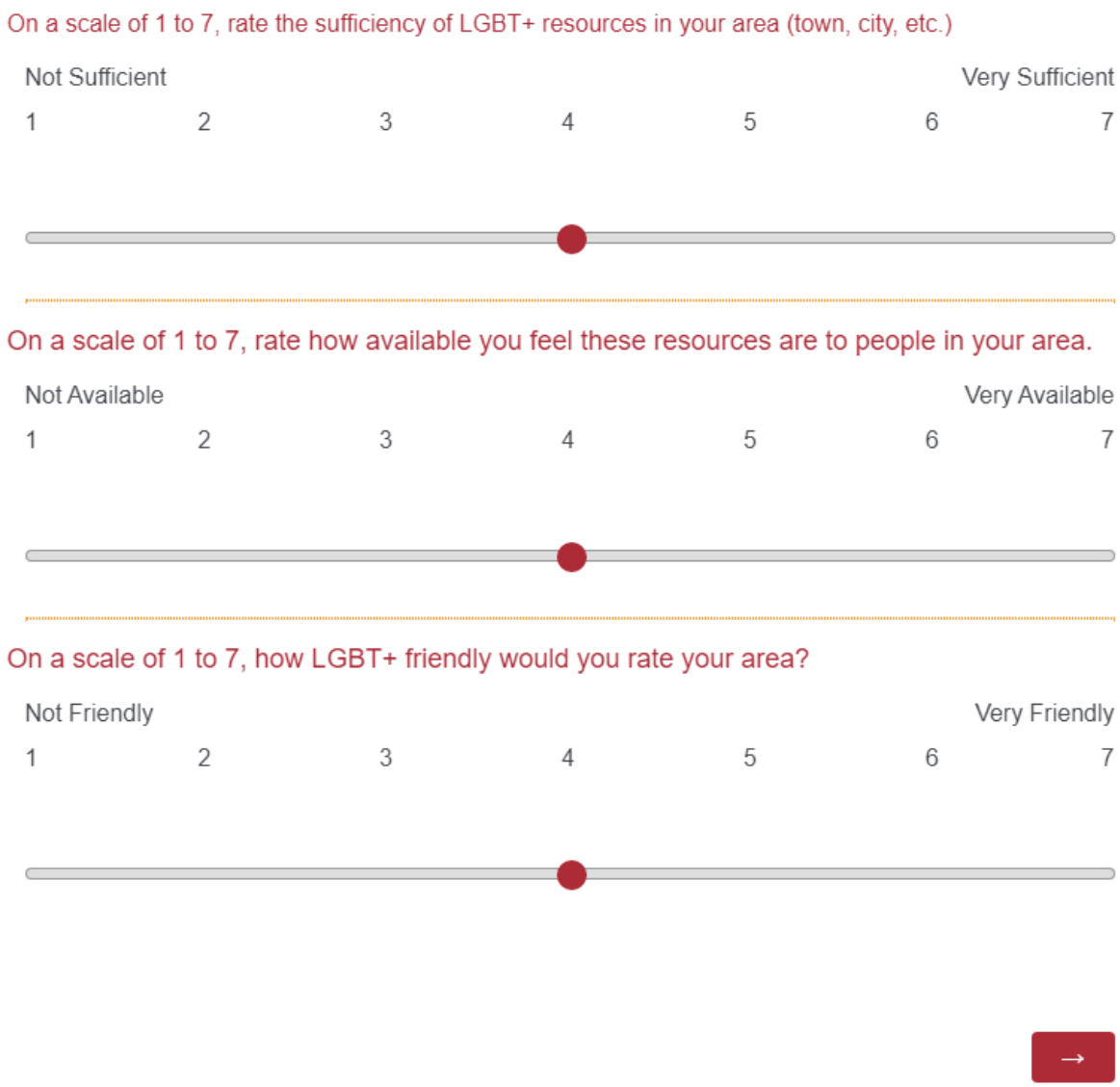

Figure 3: *Survey Page 3*

Fig. 1: A mockup visual of the proposed proximity map feature.

We want to help democratize access to LGBT+ resources for those who need it, as this access is currently heavily dependent on where a person is, what the environmental stressors are (if any), and what barriers a person faces in their personal lives.

Our first proposed app feature would showcase an exhaustive list of LGBT+ resources for any given city/town. This feature would not only list resources but also display their locations on a map for visual clarity. This map/list combination would **only** show a **registered user** the available resources if they were within city/town limits; otherwise, access to this database would be barred. A visual mockup of this feature is available (fig 1).

On a scale of 1 to 7, how useful would this feature be for you?

Not Useful At All — Extremely Useful

1 2 3 4 5 6 7

Figure 4: *Survey Page 4*

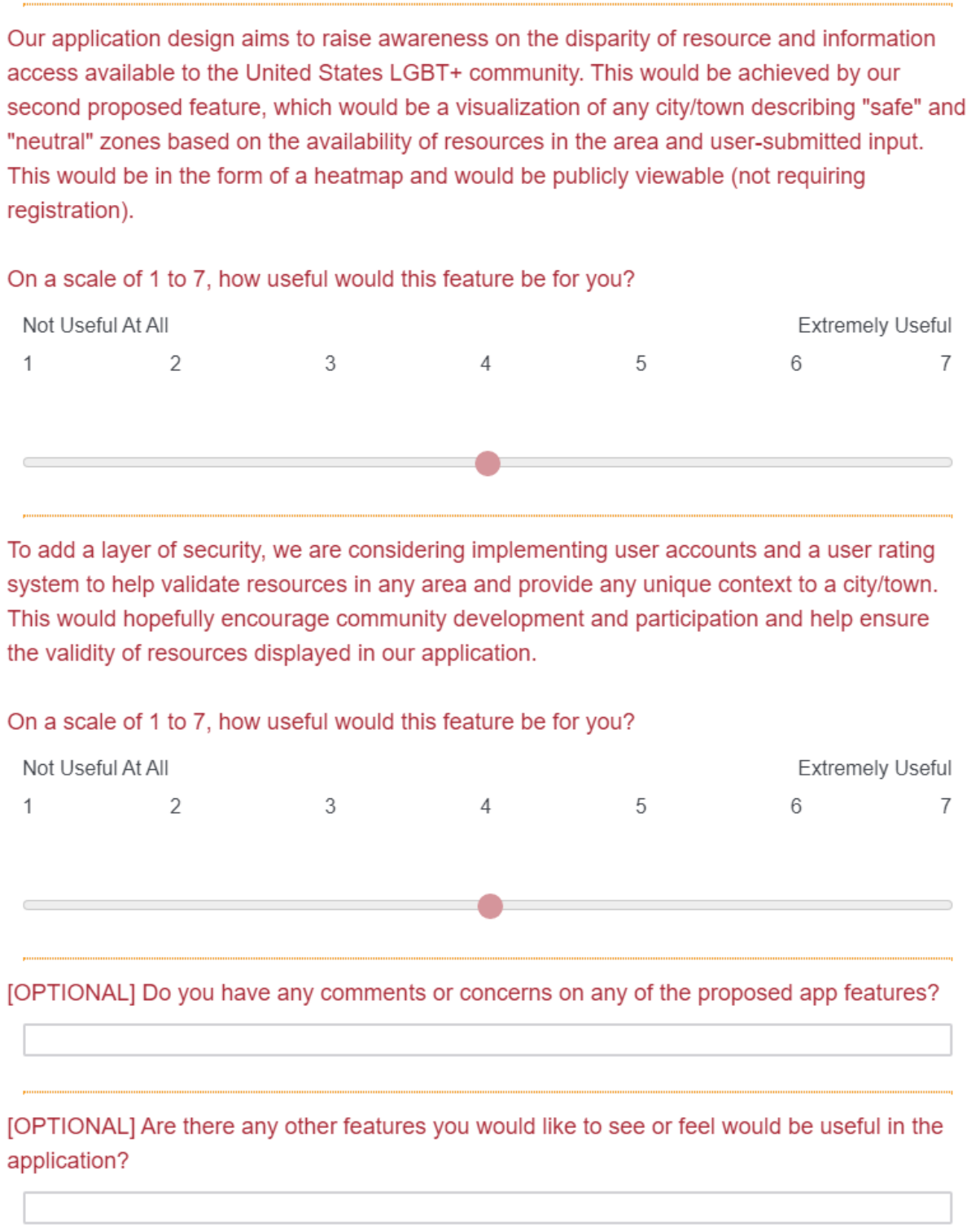

Figure 5: *Survey Page 5*

Appendix B: Adobe XD Model

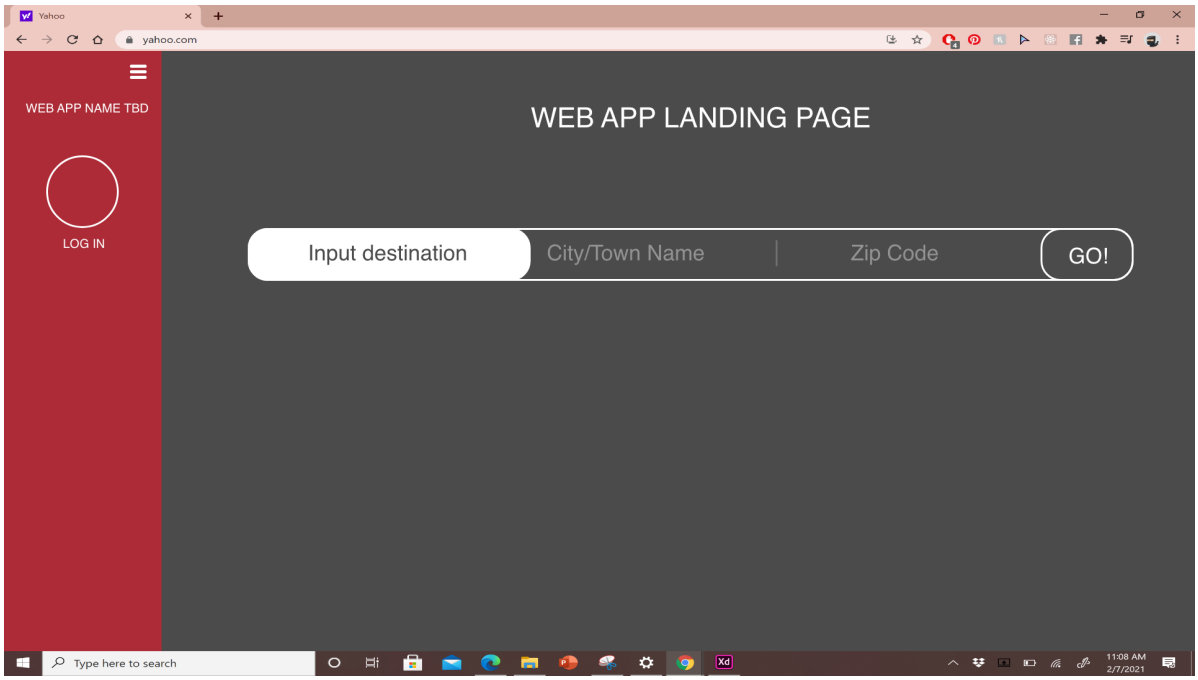

Figure 6: *A visualization of our home page.*

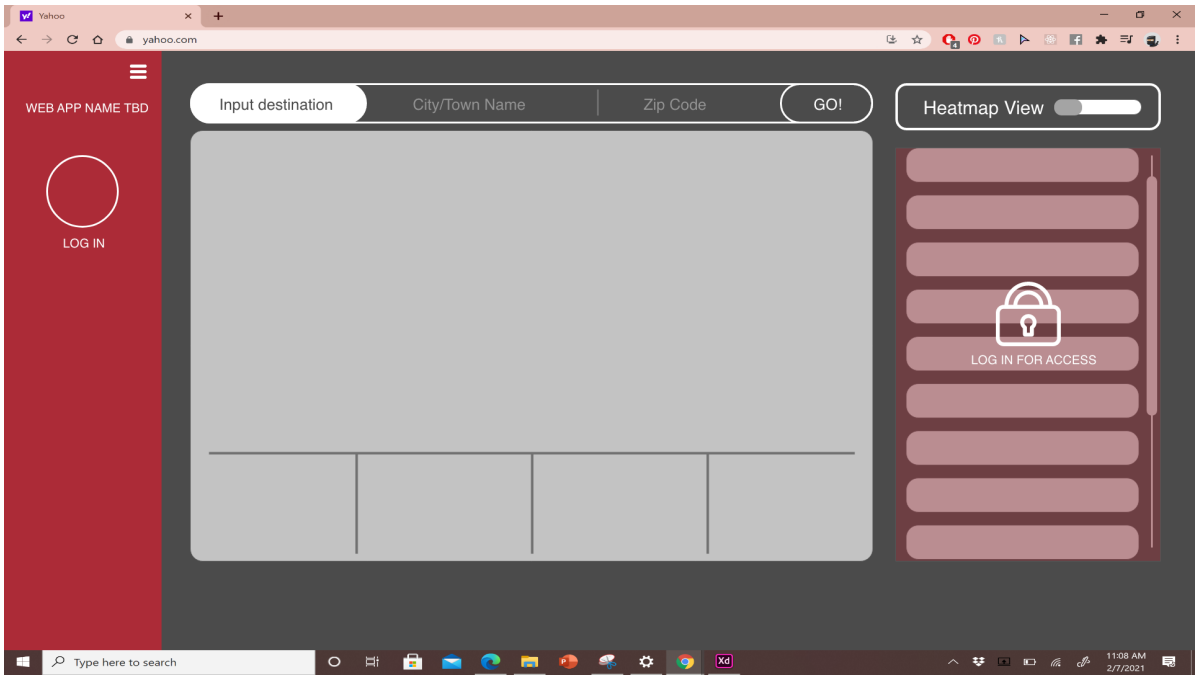

Figure 7: *A visualization of our heatmap view.*

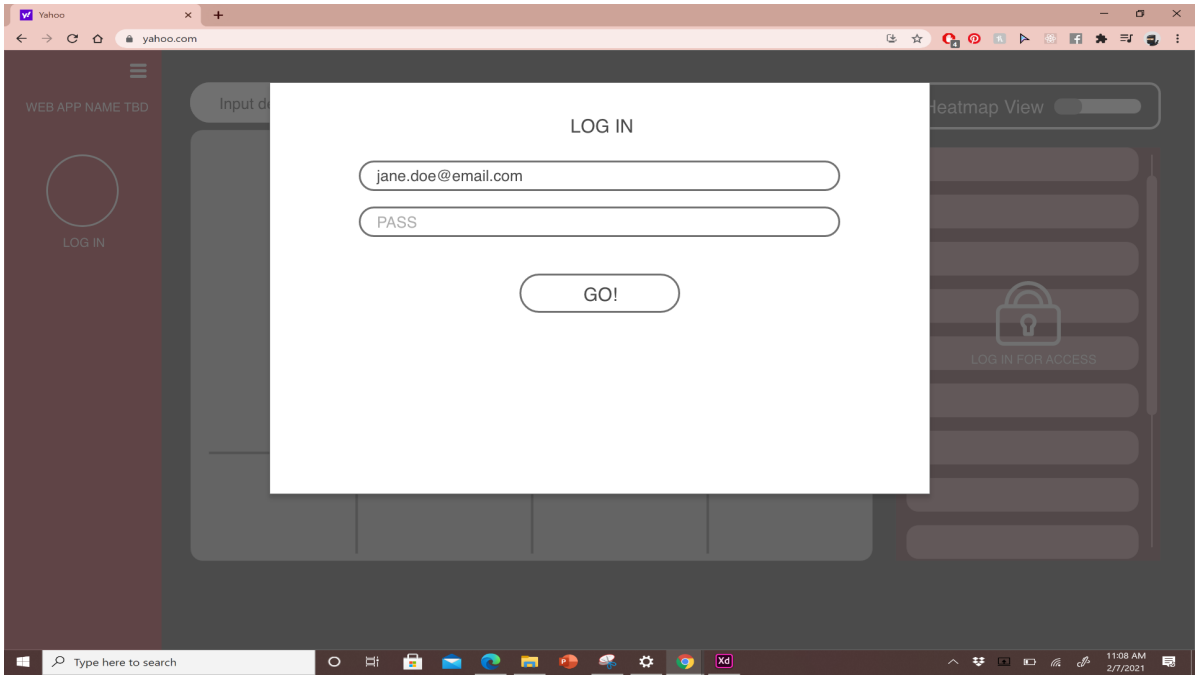

Figure 8: *A visualization of our log in.*

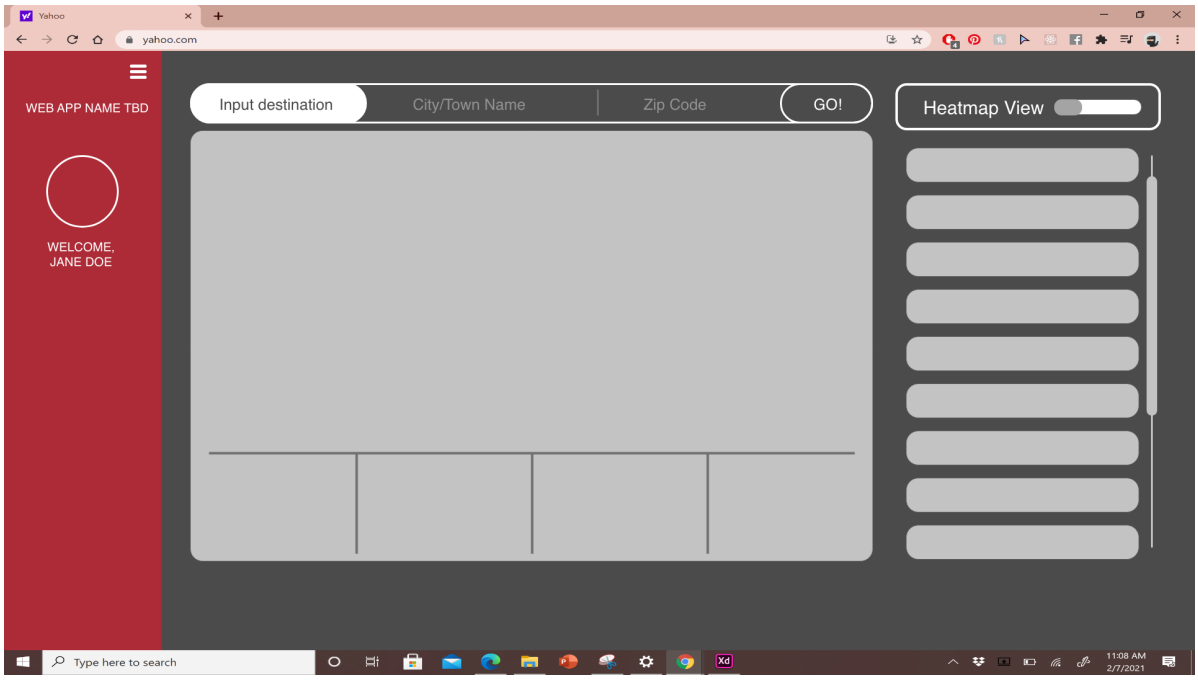

Figure 9: *A visualization of our heatmap page after log in.*

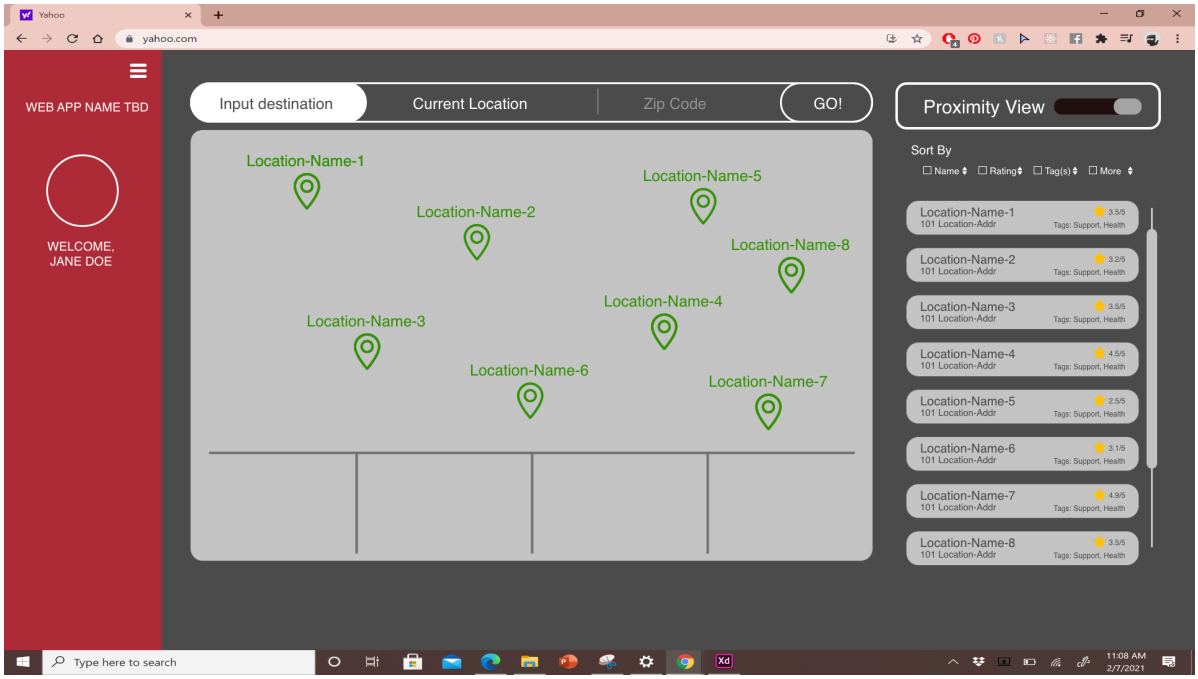

Figure 10: *A visualization of the proximity view which is viewable after log in.*

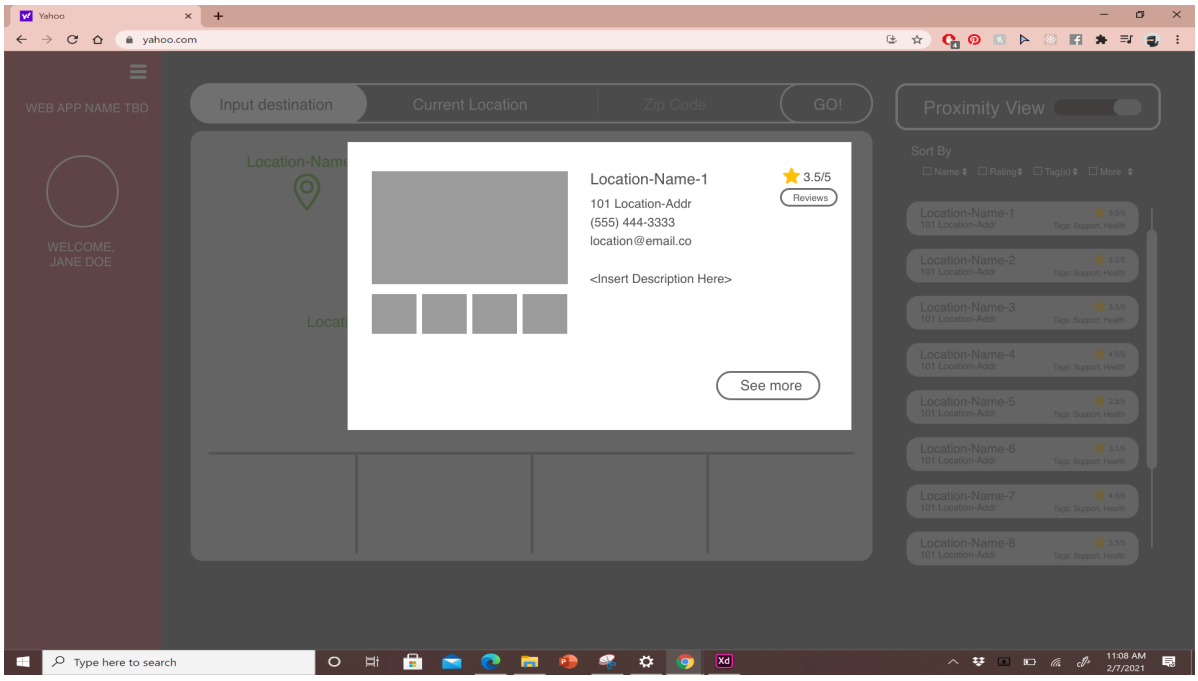

Figure 11: *A visualization of our resource pop up.*

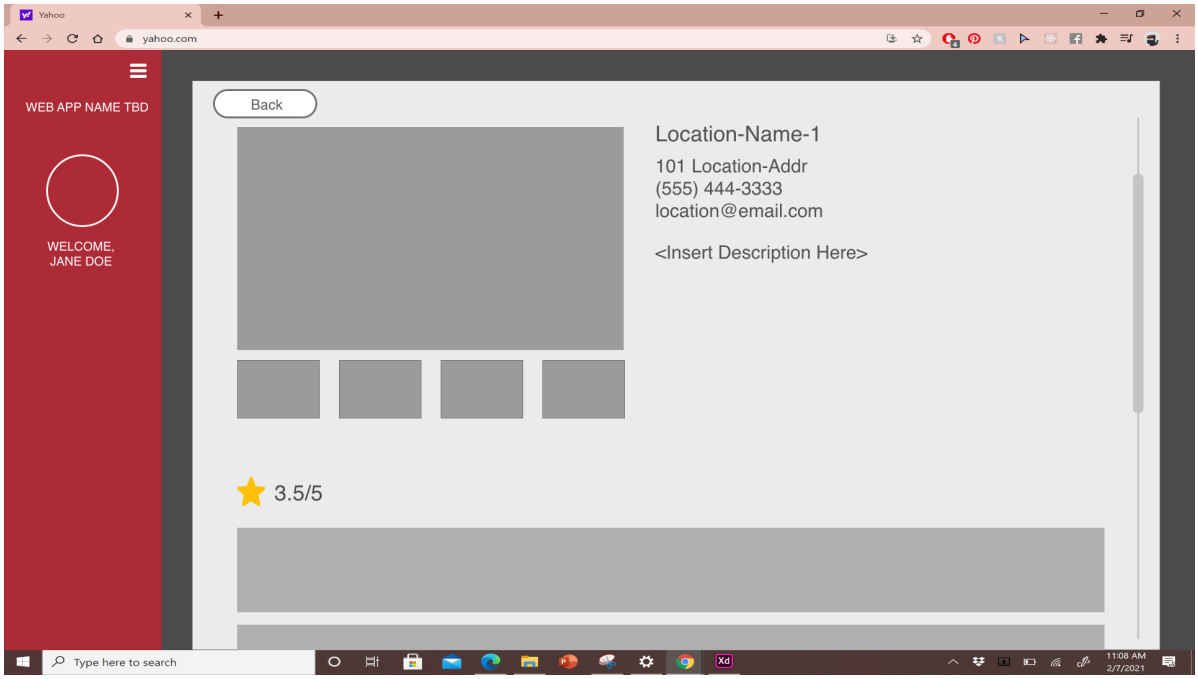

Figure 12: *A visualization of our resource description and review page.*

Appendix C: Evaluation Survey

Thank you for taking our evaluation study for our application. Before proceeding with our study, please note:

1. This evaluation will take **30-45** minutes on average. We recommend using a desktop browser for this.
2. We will be following a version of the **thinkaloud method** for usability evaluation purposes. While typically done one-on-one with an interviewer, this version is designed to be completely asynchronous. For more information, check out this link.
3. You will be prompted with **7** different tasks. Each task will first give you an opportunity to explore the application on your own (with guidance from the task). You will be given a **free response space** to write down/bullet your immediate thoughts, observations, or any other comments you might have. Feel free to write down as much as you can; the more detail you can provide, the better for us!
4. Following each task's free response space, you will be asked a few **guided questions** relating to the task. These questions can be answered in **1-2 sentences (or in bullet form)** and are **optional** if you feel you've answered them already during the free response portion of the task. They are there to help guide your thinking process as you go through the application.

Please make sure to have the application opened up on a different tab/somewhere easily accessible for you. The app can be accessed here: **https://humanitarian-app-development.web.app/**

Our project team will only record your responses for the purposes of our study. No identifying personal information will be retained, however your responses will be added to our final paper. If you have any questions, please don't hesitate to reach out to us.

Thank you,
The Humanitarian App Development MQP Team

Figure 13: *Evaluation Survey Page 1*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 1: Navigate to the landing page and describe in detail what you **see**. You may interact with the side navigation bar for this task.

Without interacting with the page, what are the most immediate features you can identify? What do you expect these features to do?

In your opinion, what seems to be the most important feature(s)?

Figure 14: *Evaluation Survey Page 2*

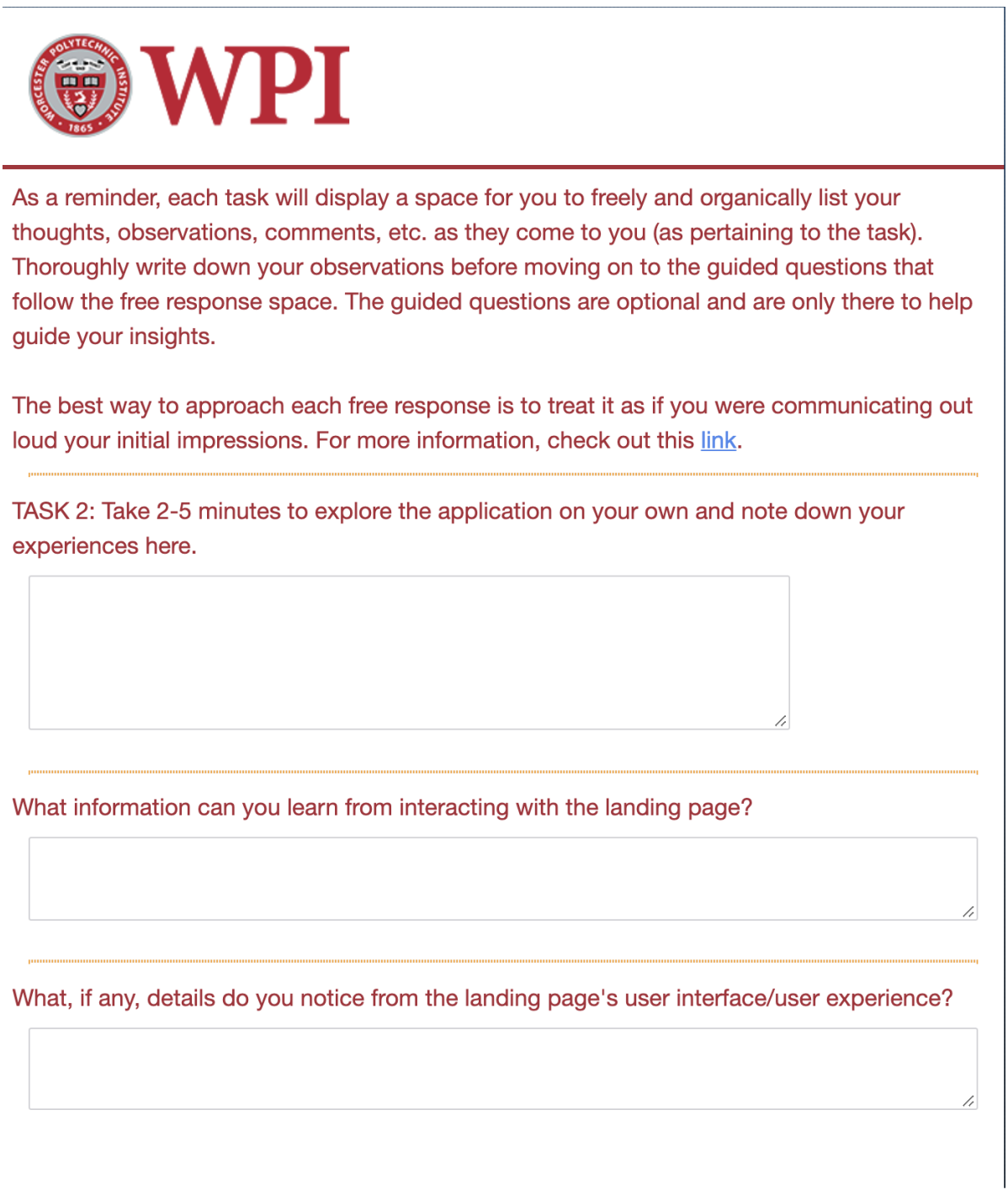

Figure 15: *Evaluation Survey Page 3*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 3: Navigate to the heatmap view. As of now, the available locations for you to observe are the greater Boston and Boston area. What is your initial impression of this page?

How easily were you able to navigate to the heatmap?

What information were you able to gather from the heatmap?

Try inputting a specific location (within the list). What do you see?

Figure 16: *Evaluation Survey Page 4*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 4: Register an account with the application.

How easily were you able to register an account?

Are the instructions clear to follow? What are you able to learn from the overlay?

Figure 17: *Evaluation Survey Page 5*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 5: Sign into the application with your new credentials.

How easy was it to sign in?

Describe in detail what you see, any concerns, etc.

Figure 18: *Evaluation Survey Page 6*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 6: Navigate to the user map view.

What is different about this view compared to the heatmap?

What information can you learn from interacting with the user map?

Figure 19: *Evaluation Survey Page 7*

As a reminder, each task will display a space for you to freely and organically list your thoughts, observations, comments, etc. as they come to you (as pertaining to the task). Thoroughly write down your observations before moving on to the guided questions that follow the free response space. The guided questions are optional and are only there to help guide your insights.

The best way to approach each free response is to treat it as if you were communicating out loud your initial impressions. For more information, check out this link.

TASK 7: Click on a location and place a review.

What information can you learn from these reviews?

How does this feature fit in with the user map feature?

What did you learn from the locations?

Figure 20: *Evaluation Survey Page 8*

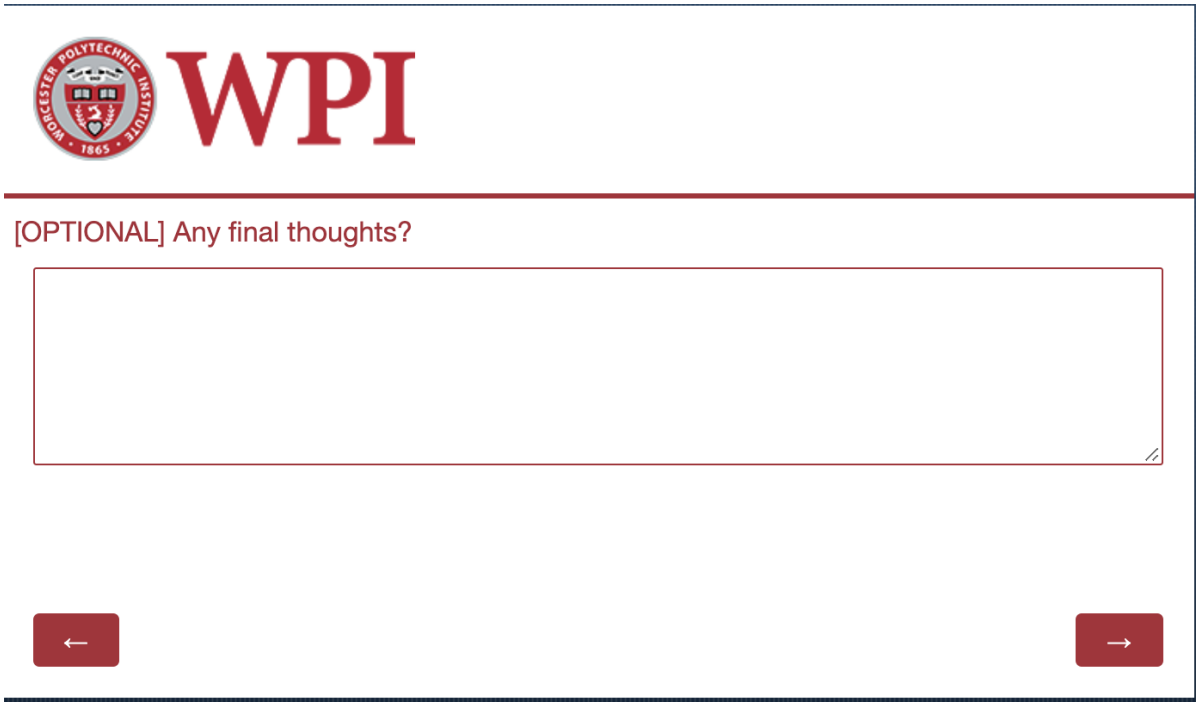

Figure 21: *Evaluation Survey Page 9*

Abbreviations

Abbreviation	Term
2FA	Two-factor Authentication
BIPOC	Black, Indigenous and People of Colour
DREAD	Damage, Reproducibility, Exploitability, Affected Users, Discoverability
GLSEN	Gay, Lesbian, and Straight Education Network
GSA	Gay Straight Alliance
HCI	Human-Computer Interaction
HHS	Department of Health and Human Services
ILGA	International Lesbian, Gay, Bisexual, Trans and Intersex Association
JWT	JSON Web Token
LGBT+	Lesbian, Gay, Bisexual, Transgender/Transsexual plus [inclusive of other groups within the LGBT+ community]
POC	People of Colour
RID	Review ID
SOGI	Sexual Orientation and Gender Identity
STRIDE	Spoofing, Tampering, Repudiation, Information Disclosure, Denial of Service, Elevation of Privilege
UI	User Interface
UID	Unique ID
UX	User Experience

Table 1: *Abbreviations used in paper.*

BIBLIOGRAPHY

[1] L. R. Mendos, K. Botha, R. C. Lelis, E. López de la Peña, I. Savelev, and D. Tan, "State-Sponsored Homophobia 2020: Global Legislation Overview Update," Tech. Rep., Dec. 2020. [Online]. Available: https://ilga.org/state-sponsored-homophobia-report

[2] "The 74 countries where it's illegal to be gay," May 2016. [Online]. Available: https://www.independent.co.uk/news/world/gay-lesbian-bisexual-relationships-illegal-in-74-countries-a7033666.html

[3] "Report on Human Rights Conditions of Transgender Women in Mexico," Cornell University Law School LGBT Clinic, Transgender Law Center, Tech. Rep., May 2016. [Online]. Available: transgenderlawcenter.org/wp-content/uploads/2016/05/CountryConditionsReport-FINAL.pdf

[4] "Movement advancement project | rural." [Online]. Available: https://www.lgbtmap.org/rural

[5] "Pricing & plans | google maps platform." [Online]. Available: https://cloud.google.com/maps-platform/pricing

[6] "Lgbtq+ travel safety – 150 best & worst countries ranked(2021)." [Online]. Available: https://www.asherfergusson.com/lgbtq-travel-safety/

[7] N. Toonen, "Toonen v. Australia, communication no. 488/1992, u. N. Doc ccpr/c/50/d/488/1992(1994) ." [Online]. Available: http://hrlibrary.umn.edu/undocs/html/vws488.htm

[8] "2006 Joint Statement," Dec. 2006. [Online]. Available: http://arc-international.net/global-advocacy/sogi-statements/2006-joint-statement/

[9] T. Onyulo, "Uganda's other refugee crisis: Discrimination forces many LGBT Ugandans to seek asylum," Jul. 2017.

[10] N. Ghoshal, "Audacity in Adversity: LGBT Activism in the Middle East and North Africa," Apr. 2018. [Online]. Available: https://www.hrw.org/report/2018/04/16/audacity-adversity/lgbt-activism-middle-east-and-north-africa

[11] A. Suliman, "Middle East survey sees patchy progress on women and LGBT+ rights," Jun. 2019, publisher: Thomson Reuters Foundation News. [Online]. Available: https://news.trust.org/item/20190624162433-z87rz/

[12] "Milestones in the American Gay Rights Movement." [Online]. Available: https://www.pbs.org/wgbh/americanexperience/features/stonewall-milestones-american-gay-rights-movement/

[13] "2015 Hate Crime Statistics," Oct. 2016. [Online]. Available: https://ucr.fbi.gov/hate-crime/2015/topic-pages/victims_final

[14] C. Curry, "9 Battles the LGBTQ Community In The US Is Still Fighting," Jun. 2017. [Online]. Available: https://www.globalcitizen.org/en/content/9-battles-the-lgbt-community-in-the-us-is-still-fi/

[15] S. K. Choi, B. Wilson, J. Shelton, and G. Gates, "Serving Our Youth 2015: The Needs and Experiences of Lesbian, Gay, Bisexual, Transgender, and Questioning Youth Experiencing Homelessness," The William Institute with True Colors Fund, Los Angeles, Tech. Rep., 2015.

[16] D. Khullar, "Stigma Against Gay People Can Be Deadly," *The New York Times*, Oct. 2018. [Online]. Available: https://www.nytimes.com/2018/10/09/well/live/gay-lesbian-lgbt-health-stigma-laws.html

[17] "The Case for Intersectionality: Supporting LGBTQ Youth Amidst COVID-19," Jun. 2020. [Online]. Available: https://www.unicefusa.org/stories/case-intersectionality-supporting-lgbtq-youth-amidst-covid-19/37418

[18] M. Davies, N. Duffy, and E. Maurice, "Almost every single queer Black household has faced serious financial problems due to COVID, troubling study finds," Dec. 2020. [Online]. Available: https://www.pinknews.co.uk/2020/12/17/movement-advancement-project-covid-pandemic-inequality-queer-black-latinx-lgbt/

[19] "The Disproportionate Impacts of COVID-19 on LGBTQ households in the U.S." [Online]. Available: https://www.lgbtmap.org/2020-covid-lgbtq-households

[20] "Homepage." [Online]. Available: https://www.glsen.org/

[21] "Providing Enhanced Resources," May 2014. [Online]. Available: https://www.hhs.gov/programs/topic-sites/lgbt/enhanced-resources/index.html

[22] "What is a GSA club?" [Online]. Available: https://gsanetwork.org/what-is-a-gsa/

[23] "Workplace Advocates." [Online]. Available: https://outandequal.org/

[24] P. Leskin, "Coming Out Online: More LGBTQ+ People Using Internet to Share Identity." Jun. 2019, publisher: Business Insider. [Online]. Available: https://www.businessinsider.com/coming-out-online-lgbtq-online-facebook-youtube-tinder-2019-5

[25] "Data privacy is crucial for the lgbt community." [Online]. Available: https://staysafeonline.org/blog/data-privacy-crucial-lgbt-community/

[26] S. Hayden, "Internet Provides Vital Connection for Africa's LGBT Communities." [Online]. Available: https://www.irishtimes.com/news/world/africa/internet-provides-vital-connection-for-africa-s-lgbt-communities-1.4305396

[27] "LGBTQ youth face higher online risks," Jun. 2016. [Online]. Available: https://www.connectsafely.org/lgbtq-youth-face-higher-online-risks/

[28] "Anti-lgbt web filtering." [Online]. Available: https://www.aclu.org/issues/lgbt-rights/lgbt-youth/anti-lgbt-web-filtering

[29] "Brief history of the internet." [Online]. Available: https://www.internetsociety.org/internet/history-internet/brief-history-internet/

[30] A. Schlesinger, W. K. Edwards, and R. E. Grinter, "Intersectional HCI: Engaging Identity Through Gender, Race, and Class," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. Denver Colorado USA: ACM, May 2017, pp. 5412–5427. [Online]. Available: https://dl.acm.org/doi/10.1145/3025453.3025766

[31] G. C. Pereira and M. C. C. Baranauskas, "Codesigning Emancipatory Systems: A Study On Mobile Applications and Lesbian, Gay, Bisexual, and Transgender (LGBT) Issues," *Journal on Interactive Systems*, vol. 9, no. 3, p. 1, Dec. 2018. [Online]. Available: https://sol.sbc.org.br/journals/index.php/jis/article/view/711

[32] D. L. Starks, T. Dillahunt, and O. L. Haimson, "Designing Technology to Support Safety for Transgender Women & Non-Binary People of Color," in *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*. San Diego CA USA: ACM, Jun. 2019, pp. 289–294. [Online]. Available: https://dl.acm.org/doi/10.1145/3301019.3323898

[33] "Custom maps | google maps platform." [Online]. Available: https://cloud.google.com/maps-platform/maps

[34] "Cryptography digital signatures - tutorialspoint." [Online]. Available: https://www.tutorialspoint.com/cryptography/cryptography_digital_signatures.htm

[35] M. Siponen, P. Puhakainen, and A. Vance, "Can individuals' neutralization techniques be overcome? A field experiment on password policy," *Computers & Security*, vol. 88, p.

101617, Jan. 2020. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0167404819301646

[36] S. Egelman, A. Sotirakopoulos, I. Muslukhov, K. Beznosov, and C. Herley, "Does my password go up to eleven? the impact of password meters on password selection," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI '13. Paris, France: Association for Computing Machinery, Apr. 2013, pp. 2379–2388. [Online]. Available: https://doi.org/10.1145/2470654.2481329

[37] D. Wheeler, "Zxcvbn: realistic password strength estimation." [Online]. Available: https://dropbox.tech/security/zxcvbn-realistic-password-strength-estimation

[38] G. Kontaxis, E. Athanasopoulos, G. Portokalidis, and A. D. Keromytis, "SAuth: protecting user accounts from password database leaks," in *Proceedings of the 2013 ACM SIGSAC conference on Computer & communications security*, ser. CCS '13. Berlin, Germany: Association for Computing Machinery, Nov. 2013, pp. 187–198. [Online]. Available: https://doi.org/10.1145/2508859.2516746

[39] "Shibboleth authentication request." [Online]. Available: http://ezpxy-web-p-u01.wpi.edu/login?url=http://search.proquest.com/?accountid=29120