The Binary in the Binary: Women's Persistence and Advancement in the Technology Industry

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i. Abstract

The main objective of this research is to investigate women's careers in tech. The purpose of the dissertation is to identify the factors that influence women's persistence and advancement in the tech industry. With the ultimate goal of feminist research in mind, identifying, documenting, and collecting data on these issues is crucial to bring about social change in the industry and achieve equality.

This dissertation attempts to understand and record the gender inequality in the tech industry and does so by conducting an extensive literature review informed by intersectional liberal feminism. The literature review discusses three major themes, namely: individual experience, culture, and career progression.

This research underpins the design and agile development of the Binary in the Binary project, a proposal for a research tool used to test people's perceptions on how gender affects career progression in the tech industry. The Binary in the Binary is a PostgreSQL database-driven responsive web application coded in PHP and JavaScript and run on the open-source Apache HTTP Server. The dissertation explains the development of the Binary in the Binary web application that uses the Model View Controller (MVC) design pattern.

This dissertation provides evidence that the Binary in the Binary project proposal is indeed feasible and that the study is an important one with great relevance to gender parity in the technology industry.

ii. Declaration

I have read and understood the College and Departmental statements and guidelines concerning plagiarism. I declare that:

- This submission is entirely my own original work.
- Wherever published, unpublished, printed, electronic or other information sources have been used as a contribution or component of this work, these are explicitly, clearly, and individually acknowledged by appropriate use of quotation marks, citations, references and statements in the text. It is 12 097 words in length.

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III. List of Abbreviations

CSS	Cascading Style Sheets
CSV	Comma-Separated Values
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
MVC	Model View Controller
OOP	Object Oriented Programming
PDO	PHP Data Objects
PHP	Hypertext Pre-processor
SoC	Separation of Concerns
SQL	Structured Query Language
UI	User Interface
UK	United Kingdom
UN	United Nations
URL	Uniform Resource Locator
US	United States of America
UX	User Experience

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This dissertation is for all the women in tech. We have got this!

1. Introduction

Women have been instrumental in both the inception and development of technology. Ada Lovelace wrote the first program (Charman-Anderson, 2015). Kay McNulty, Betty Jennings, Betty Snyder, Marlyn Meltzer, Fran Bilas, and Ruth Lichterman programmed the first fully functional digital computer (Odetta, 2021; Criado Perez, 2019). Katie Bouman developed the algorithm to image black holes (Dunbar and Caldwell, 2021).

However, the technology industry is widely regarded as a masculine domain (González-González et al., 2018; Hesselbein, 2020; Holtzblatt and Marsden, 2022; Lemons and Parzinger, 2007; Malloy and Smith, 2019). The technology industry, often shortened to the tech industry and used interchangeably, comprises companies that design, develop, or distribute technological products or services (Corporate Finance Institute, 2022; Global Edge, 2022).

The main objective of the research presented in this dissertation is to investigate women's careers in tech. The purpose of this study is to identify the factors that influence women's persistence and advancement in the tech industry. This dissertation attempts to understand and document the gender inequality in the tech industry and does so, in the first instance, by conducting an extensive literature review informed by intersectional liberal feminism. The dissertation provides a discussion on women's individual experience in the tech industry. This includes the effects of social identity and a lack of confidence. Next, the dissertation addresses the tech industry's individualistic, heteronormative, male-dominated workplace culture (Hardey, 2019; Hamer, 2019). This section considers sexual harassment, the myth of the unencumbered worker (Criado Perez, 2019), and the importance of diverse teams. Finally, the literature review details how visibility and likeability, women in leadership, a lack of mentors

and role models, and networks, influence women's career progression in the technology industry.

Criado Perez (2019) is of the opinion that collecting data about "old injustices" is crucial to discontinuing them (p. 107). Accordingly, the dissertation details the design and development of the Binary in the Binary proof-of-concept web application, a research tool used to test people's perceptions on how gender affects career progression in the tech industry and to track these perceptions to ascertain if there is any improvement over time. I developed the Binary in the Binary proof-of-concept web application because I wanted to combine the topic of gender equality in the technology industry, something which I am passionate about, with my technology skills.

The Binary in the Binary project is a PostgreSQL database-driven web application written in PHP and JavaScript and run on the open-source Apache HTTP Server. The study explores the agile approach implemented in the development of the proof-of-concept web application. Additionally, it details how the development of the Binary in the Binary followed the Model View Controller (MVC) design pattern, in which code is separated into three distinct layers, each handling an aspect of the application. The model layer consists of the database and code that allow a user to interact with the data. The view layer contains the HTML templates used to present data to the user. The controller layer processes the user's interaction.

Implementing a thought-through and simple user interface (UI) and user experience (UX) was a critical aspect of the project. I created a style guide and detailed user interface mock-ups for both the desktop and mobile versions to follow during development. The Binary in the Binary web application is responsive to ensure it is aesthetically pleasing and usable on devices of

varying sizes. The dissertation presents descriptions and figures showing the Binary in the Binary project.

In addition, the dissertation addresses the matter of additional recommended processes and features that should be improved or incorporated in the Binary in the Binary project if it is implemented. The most significant suggestion is that it should take on a more intersectional approach. To achieve this, I suggest that it should include functionality to test how ethnicity and the intersection of gender and ethnicity influences people's perceptions about career progression in the tech industry.

Feminist research has the ultimate goal of social change and equality (Webb and Young, 2005). Research and data collection on women's persistence and advancement in the tech industry is crucial for multiple reasons. Firstly, this research is important for women entering and participating in the industry because it informs them of potential obstacles in their careers. In addition, it is important to educate men about women's experiences in tech. Finally, leadership can make good use of this research and data to elicit change in the tech industry.

2. Literature Review

Women hold less than 25 percent of roles in tech (Hamer, 2019). This lack of gender equality in the workforce is an issue at the largest and most prominent US tech companies: Amazon, Apple, Facebook, Google, and Microsoft (see Figure 1).

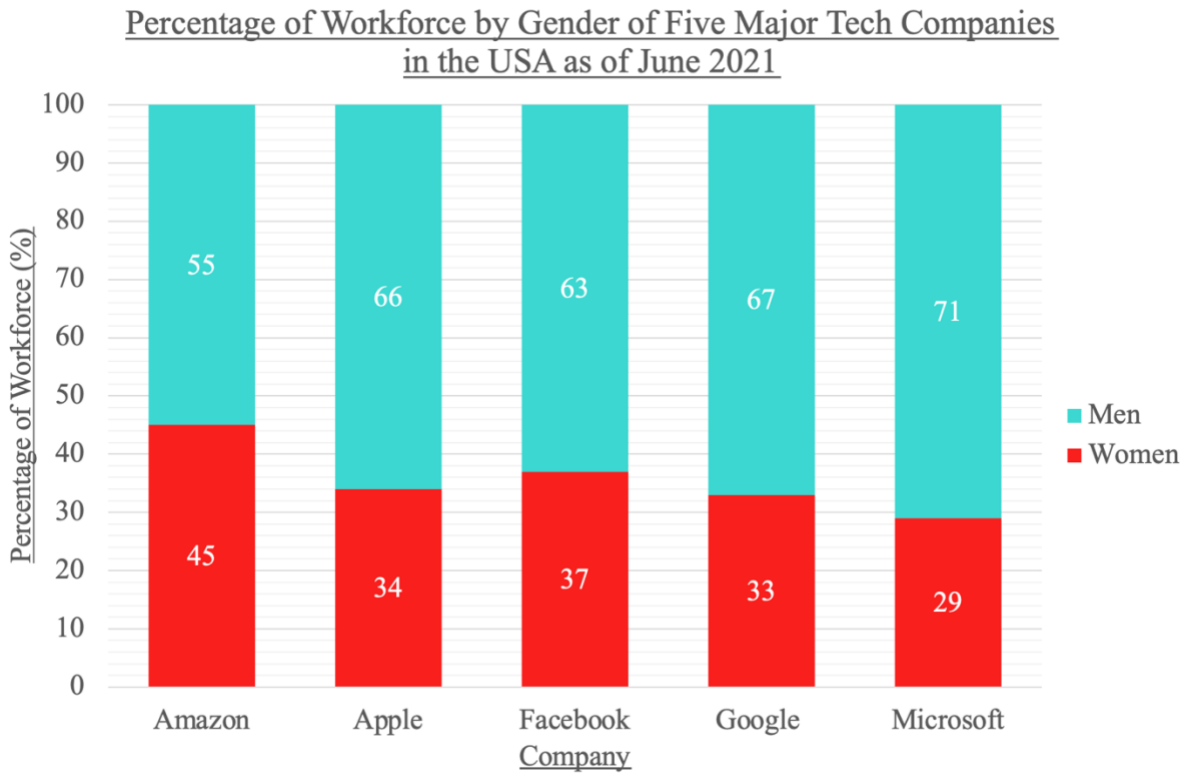

Figure 1: Stacked bar chart showing the percentage of the workforce by gender at five major US tech companies as of June 2021 (Richter, 2021)

More than 40 percent of women who begin their careers in the tech industry leave in comparison, only 17 percent of men leave to seek other employment (Epsztajn, 2019; González-González et al., 2018; Holtzblatt and Marsden, 2022; Criado Perez, 2019; Schmitt et al., 2020). Companies fail to retain the women they employ and do not hire women at the same rate that they leave (Correll and Mackenzie, 2016; Malloy and Smith, 2019). Chau and Quire

(2018) explain that any attempts to combat the barriers women who work in male-dominated industries face, requires the recognition of women's experiences and views.

This literature review focuses on women's persistence and advancement in the tech industry. This work is crucial because although the industry "does not exclude women, it does little to promote them or to retain them" (Lemons and Parzinger, 2007, p. 91).

2.1. Gender and Feminism

The concept of gender is paramount to this research. Gender relates to cultural and social differences in identity, expression, and experience (Australian Bureau of Statistics, 2021). This dissertation considers all individuals who identify as women.

According to Rosser (2005), using a feminist lens to interrogate the tech industry enables one to "uncover subtle, rich insights into the dynamics of gender and technology (p. 1)." This research is informed by both intersectional and liberal feminism. Embracing the term intersectionality moves liberal feminism into a more progressive space as liberal feminism focuses traditionally on the white, middle-class experience.

2.1.1. Liberal Feminism

Liberal feminism argues that women are oppressed because they face unjust gender-based discrimination (Jaggar, 1983). Liberal feminists advocate for "equal consideration without discrimination on the basis of sex" (Rosser, 2005, p. 2). This is achieved by ensuring equality of legal rights and using legislation as a tool to resolve unjust treatment (Almeder, 1994; Wendell, 1987). Additionally, liberal feminism encourages the recognition of the value of women by both women and by others (Wendell, 1987). Within the tech industry, a liberal

feminist stance explains that a focus on the current employment, access, and discrimination issues can resolve the gender-stratified labour market (Rosser, 2005).

2.1.2. Intersectional Feminism

Intersectional feminism, a term coined by Kimberlé Crenshaw in 1989, challenges one to think about women's lived realities as dynamic, complex, subjective, and irreducible and their oppression as multidimensional (Samuels and Ross-Sheriff, 2008; Showunmi, 2020; Levine-Rasky, 2011; Brah and Phoenix, 2004; Phoenix and Pattynama, 2006). According to UN Women (2020), intersectional feminism "centres the voices of those experiencing overlapping, concurrent forms of oppression in order to understand the depths of the inequalities and the relationships among them in any given context." Although it is not an extensive list, this dissertation addresses the following identity categories: gender and ethnicity. An intersectional feminist approach is crucial to this research as it is simplistic to argue for the importance of gender equality in the tech industry without acknowledging other social identities and the resulting compounded experiences of discrimination.

2.2. Down to the 0s and 1s – The Individual Experience

The stereotypical coder is a geeky, white, cisgender man with poor social skills (Lemons and Parzinger, 2007; Criado Perez, 2019). This is due to a 1967 psychological paper that identified a "disinterest in people" and a dislike of "activities involving close personal interaction" as a "striking characteristic of programmers" (Criado Perez, 2019, p. 106). Employers used these characteristics as hiring requirements, and the resultant gender bias is still evident in the industry (González-González et al., 2018; Schmitt et al., 2020).

2.2.1. Social Identity

Social identity theory states that social identity, a person's sense of who they are, is based on group membership(s), which act(s) as a source of pride and self-esteem, and provides a sense of belonging (Malloy and Smith, 2019). This social categorisation enables the formation of an in-group and an out-group, with the in-group discriminating against members of the out-group to enhance their self-image (Malloy and Smith, 2019). Within the tech industry, the in-group consists of white men and the out-group of women and ethnic minorities (Malloy and Smith, 2019). It is unsurprising, then, that "women suffer additional disadvantages in the workplace depending on how strongly aligned they are to other roles and identities" (Hardey, 2019, p. 50). Traditionally, women are associated with communal traits, while men are associated with agentic characteristics (Arnold and Loughlin, 2019). As a result, women in the workplace do additional undervalued and unrecognised work because they are penalised if they do not do so (Criado Perez, 2019).

Consequently, many women in male-dominated industries, including tech, undertake identity work to fit in and be "one of the guys" (Hardey, 2019; Sandberg, 2015, p. 144). Thereby, they de-feminise themselves and emphasize more typically masculine characteristics (Hardey, 2019). This includes talking, acting, and dressing in a stereotypically masculine manner (Hesselbein, 2020). A Silicon Valley CEO stated: "I dress like a man, so I don't get accused of being the wife, secretary or a hooker" (Hardey, 2019, p. 63). Other tactics include accepting the drinking culture, pretending to enjoy sports, and playing golf (Lemons and Parzinger, 2007). However, attempting to "fit in" strengthens the idea that women do not belong (Gates, 2019).

2.2.2. Confidence

Social identity, and the associated group expectations, affect one's confidence and view of what one "can and should accomplish" (Sandberg, 2015, p.19). A lack of confidence is one of the main obstacles preventing women from succeeding in the tech industry (Epsztajn, 2019). A lack of confidence means that women underestimate their skills (Chau and Quire, 2018). Women show "reluctance to promote themselves and to believe in their abilities" (Epsztajn, 2019, p. 2). However, these characteristics are crucial for career success in male-dominated industries (Hamer, 2019). Additionally, negative feedback affects women's self-confidence more than men's (Chau and Quire, 2018). According to Criado Perez (2019), this lack of confidence is because gender norms prescribe women to be modest. Thus, Epsztajn (2019) argues that women need to be more self-reliant. However, this is much easier in theory than in practice.

While women assess their intelligence accurately, averagely intelligent men think they are smarter than two-thirds of people (Criado Perez, 2019). It is unsurprising then, that men's success is attributed to intelligence, whereas women's success is attributed to luck. Furthermore, women's failure is attributed to a lack of ability, whereas men's failure is attributed to bad luck (Lemons and Parzinger, 2007). As a result, women have to prove themselves and to justify their position in tech (Chau and Quire, 2018; Sandberg, 2015). Furthermore, women do additional work to compensate and validate their abilities to their male counterparts (Chau and Quire, 2018; Epsztajn, 2019). A woman quoted in Hardey's (2019) book states: "I use my tech expertise to get men over the disappointment of my gender. (p. 67)"

2.3. The Whole Program – Culture

Significant research attributes the low retention of women in the tech industry to the workplace culture (González-González et al., 2018; Hamer, 2019; Criado Perez, 2019; Lemons and Parzinger, 2007; Schmitt et al., 2020). The heteronormative, male-dominated workplace culture in the tech industry "intensively, sometimes aggressively, ensures" difference rather than equality and sustains the lack of diversity (Hardey, 2019, p.45). The hostile, individualistic, exclusive, and competitive environment affects women's participation and sense of belonging in the tech industry (Hamer, 2019; Schmitt et al., 2020). According to Hamer (2019), women also experience workplace sexism and prejudicial treatment through discriminatory language. For example, in Silicon Valley, the term "grinding in" describes an aggressive initiation in a new employee's probation period (Hardey, 2019, p. 58).

2.3.1. Sexual Harassment

Given the male-dominated culture in the tech industry, it is unsurprising that sexual harassment is pervasive (Hamer, 2019). The Elephant in the Valley (2017) project unveils senior-level women's issues in the workplace in Silicon Valley. According to the survey data, one in three women has doubted her safety due to work-related circumstances (The Elephant in the Valley, 2017). The same survey shows that 60 percent of women in tech have received unwanted sexual advancements, and half of those received them more than once (The Elephant in the Valley, 2017). Furthermore, according to Women in Tech's State of Women in Tech Report 2020, 85 percent of the women who participated in the survey explained that after reporting harassment, the persecutor faced no repercussions (Kapin, 2020; Women Who Tech, 2020).

2.3.2. The Encumbered Worker

The traditional workplace culture is "tailored to the life of a mythical unencumbered worker" that men are more likely to assimilate (Criado Perez, 2019, p. 85). According to the European Institute for Gender Equality (2016), unpaid work, including house and care work, produces goods and services but does not receive remuneration or payment. In the US, women do four hours of unpaid work per day, compared to men's two and a half hours (Wezerek and Ghodsee, 2020). In the UK, women do 60 percent more unpaid work than men (Neitzert, 2020). Companies should account for the additional work women do to enable women to participate fully in the tech industry.

Furthermore, according to Criado Perez (2019), current workplace culture incorrectly equates long working hours with effectiveness. This is detrimental to women who have to factor more unpaid labour into their schedules. Thus, it is unsurprising that in the UK, 75 percent of all part-time workers are women (Criado Perez, 2019). However, part-time work pays less than full-time work. Thus, when considering jobs, women must weigh up flexibility and remuneration.

2.3.3. Diverse Teams

Ensuring that more women succeed in the tech industry is paramount to creating a diverse workforce. Diverse teams are crucial because a more gender and ethnically diverse workplace challenges the notion that only white men belong in the tech industry (Hardey, 2019).

Research attributes increased innovation and better decision-making to a diverse and inclusive workforce (Del Carpio and Guadalupe, 2022; González-González et al., 2018). Men-only teams fail to match the varied viewpoints and insights of diverse teams (Del Carpio and

Guadalupe, 2022). Teams dominated by men may introduce products that are useful from the male perspective with user and design biases (Rosser, 2005). However, teams comprised of people with different backgrounds, perspectives, and concerns reflect the wants and needs of the product users more accurately (Schmitt et al., 2020). This is especially important in the tech industry because the products directly influence life in the twenty-first century (Gates, 2019).

Furthermore, organizations benefit from diverse teams (Malloy and Smith, 2019). With a more diverse workforce, companies will produce a wider variety of products that satisfy more customers with different needs (Schmitt et al., 2020). This increases organizational competitiveness and performance (Malloy and Smith, 2019). Additionally, research attributes more effective governance styles to diverse teams (González-González et al., 2018).

Leadership plays a crucial role in creating and sustaining the workplace culture (McKinsey & Company, 2021). The men dominating the leadership positions are instrumental in ensuring gender equality in the tech industry. Men must embrace change fully if they are to transform the tech sector into an unprejudiced industry (Epsztajn, 2019). This includes intentionally hiring and promoting more women (Sandberg, 2015). Arnold and Loughlin (2019) argue vehemently that "[w]hen men in power decide to 'lean in' for change they can redefine or rectify who sits at the table virtually overnight. (p. 2)"

A significant culture change is needed to ensure that the tech industry retains women. This requires a conscious effort by businesses to ban sexist behaviour and facilitate a diverse company culture (Epsztajn, 2019). González-González et al. (2018) argue that organizations must celebrate women and make them visible within the workplace. Companies should implement strategies that "empower women to exploit their existing potential and removes

obstacles in the long term", including training, workshops, and network creation (Schmitt et al., 2020, p. 13). However, "[i]deological male bias doesn't simply arise at a workplace level: it is woven into the laws that govern how employment works. (Criado Perez, 2019, p. 89)" Thus, broader society needs a cultural change to one that supports women (González-González et al., 2018).

2.4. Running the Program – Career Progression

2.4.1. Women's "Abilities" – Visibility and Likeability

Women do not receive promotions at the same rate as men; thus, they feel stalled in their careers, and leave the industry (Correll and Mackenzie, 2016). A survey respondent to Lemons and Parzinger's (2007) study explains that this is because women have to fight for visibility in career progressing projects. This is detrimental as this work is instrumental to acquiring promotions and, eventually, leadership positions (Correll and Mackenzie, 2016).

Furthermore, women's likeability affects their ability to land choice assignments and career opportunities (Correll and Mackenzie, 2016). Likeability and success are positively correlated for men and negatively correlated for women (TED, 2010). This phenomenon is called the double bind, a situation in which women are considered either likeable or competent, but not both (Costigan, 2018). Specific characteristics, such as assertiveness and strength, are advantageous for men but disadvantageous for women (Correll and Mackenzie, 2016; Sandberg, 2015). In fact, according to The Elephant in the Valley (2017) survey, 84 percent of women in tech have been told they are too aggressive. This helps explain why "women receive negative personality criticism that men simply don't" (Criado Perez, 2019, p. 93; Snyder, 2014). Women are labelled demanding and bossy, whereas men are seen as drivers (Correll and Mackenzie, 2016).

2.4.2. Women in Leadership

There is a lack of women in leadership positions in the tech industry (Chau and Quire, 2018; Hardey, 2019; Malloy and Smith, 2019). Like the workforce (see Figure 1), the 2021 division of leadership by gender at the five major US tech companies (Amazon, Apple, Facebook, Google, and Microsoft) is not equal (see Figure 2). Women are crucial in leadership roles because they challenge the notion that women do not belong in these positions and change perceptions about women's competence (Arnold and Loughlin, 2019). Additionally, women in leadership roles means that women's needs and wants are more likely to be addressed (Sandberg, 2015). However, women only account for 9 percent of executive roles in the tech industry (Hamer, 2019). According to the McKinsey 2021 Women in the Workplace report, "women are promoted to manager at far lower rates than men, and this makes it nearly impossible for companies to lay a foundation for sustained progress at more senior levels." Consequently, there is a misalignment in the number of women in middle management and the number of women in upper or senior management (Chau and Quire, 2018).

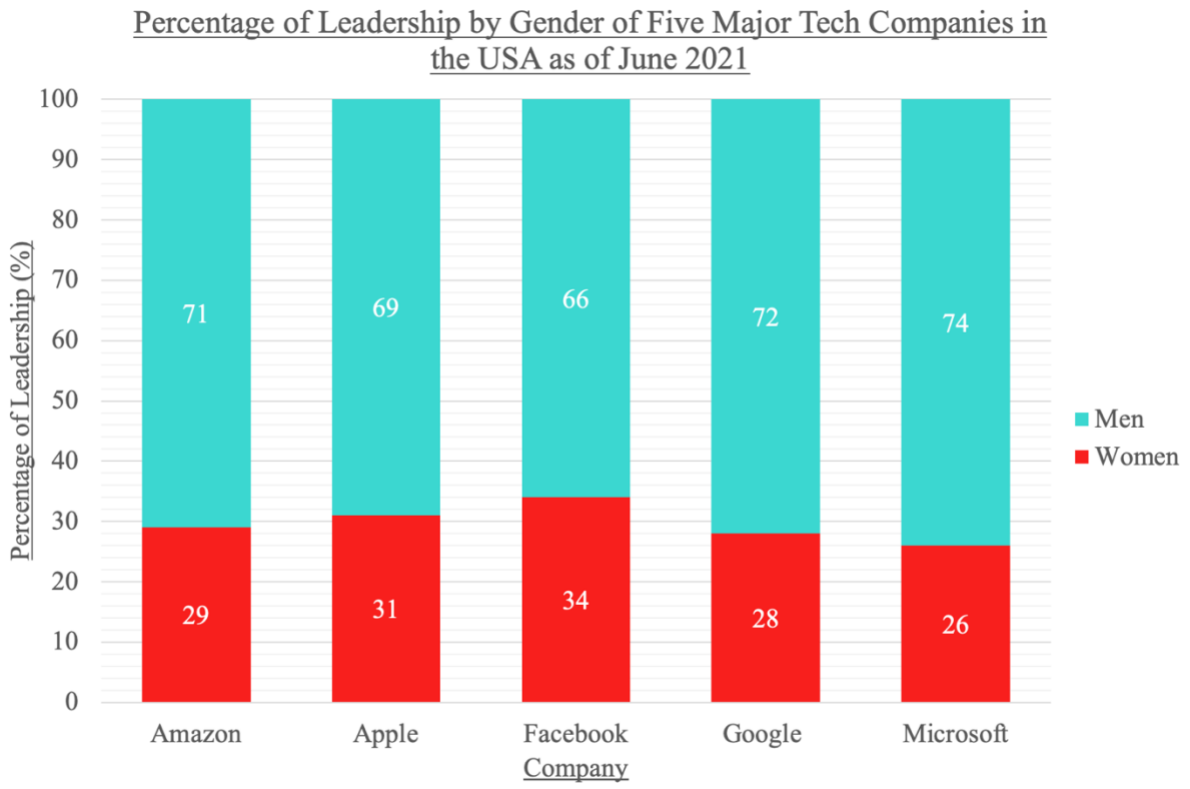

Figure 2: Stacked bar chart showing the percentage of leadership by gender at five major US tech companies as of June 2021 (Richter, 2021)

Gender parity should be a priority in the tech industry. Organizations can help to achieve this by requiring mandatory representation of women at all levels (Arnold and Loughlin, 2019). A London School of Economics study found that quotas identify and eradicate substandard men rather than the unjustified common belief that they promote inadequate women (Chapman, 2017). This method of promotion would be ideal in the tech industry, which is plagued by another unjustified common belief, namely that meritocracy is a reality rather than the ideal (Criado Perez, 2019). This is detrimental to women in so-called meritocratic organizations, where "managers favour male employees over equally qualified female employees (Criado Perez, 2019, p. 94)".

2.4.3. Lack of Mentors and Role Models

The lack of women in leadership positions results in a lack of women mentors and aspirational role models in the tech industry (González-González et al., 2018). According to Sandberg (2015), "[m]ost positions are held by men, so women don't expect to achieve them, and that becomes one of the reasons they don't. (p. 22)" Mentors and role models increase women's likelihood of remaining in the tech industry and are beneficial to career progression and leadership development (Hamer, 2019). Advantages gained from these relationships include support, networking opportunities, and confidence building (Hamer, 2019).

These relationships can be forged individually or through formal programs. However, women who acquired mentors on their own are 50 percent less likely to receive a promotion than women who used formal programs (Sandberg, 2015). It is important to note that while men find mentors more easily than women, women of colour have an increasingly difficult time acquiring mentor relationships (McKinsey & Company, 2021).

2.4.4. Networks

Another impediment to women's career progression in the tech industry is the dominance of male-dominated networks, colloquially known as the Old Boys Club (Tattersall and Keogh, 2006; Webb and Young, 2005). Women are unlikely to or intentionally prevented from accessing these networks and reaping the associated rewards. However, networks are paramount for building connections, gaining support, and accessing career resources (Correll and Mackenzie, 2016; Hamer, 2019).

Much research expresses the importance of women-only networks that create safe spaces for women in tech (Hamer, 2019; Schmitt et al., 2020; Tattersall and Keogh, 2006; Webb and

Young, 2005). Women-only networks provide a sense of community and belonging, build confidence, and enable knowledge sharing (Hamer, 2019; Schmitt et al., 2020). Thus, companies should encourage and facilitate women's networks to challenge the current culture and retain women in tech.

To ensure that women in tech succeed and are able to rectify the current gender inequality in the industry, it is crucial to identify and understand the factors that prohibit women's persistence and advancement in this male-dominated sector. This intersectional liberal feminist-informed literature review discusses the women's individual experience, the culture in the tech industry, and career progression.

3. The Algorithm – The Methodology

My research about women in tech and the development of the Binary in the Binary web application, a tool to gather data on people's gendered perceptions on career progression in the tech industry, was motivated by the following quote: "But if you aren't aware of how those biases operate, if you aren't collecting data and taking a little time to produce evidence-based processes, you will continue to blindly perpetuate old injustices (Criado Perez, 2019, p. 107)."

3.1. Research Questions

The main objective of the research presented in this dissertation is to investigate women's careers in tech. More specifically, the dissertation aims to identify the factors that influence women's persistence and advancement in the tech industry. To address this objective, the two main questions are:

- What factors influence women's persistence in the technology industry?
- What factors influence women's advancement in the technology industry?

3.2. Research Paradigm

A paradigm is the basic set of beliefs that guide action (Pickard, 2013). This research is informed and guided by an interpretivism paradigm. This paradigm acknowledges that in the social world, people constantly make and reproduce meanings. Interpretivists take a relativist, ontological stance. This ontological approach recognises the existence of multiple, complex, social context- and time-bound constructed realities of the individual (Pickard, 2013). Interpretivists use a subjective epistemology, meaning that the results of an investigation are a direct product of the interaction between the investigator and the subject (Pickard, 2013).

When using an interpretivist research philosophy, the researcher is an "integral part of the research situation" and her/his values and background impacts the outcomes of the study (Webb and Young, 2005, p. 150). Furthermore, like Showunmi (2020), I believe that personal experiences shape one's scholarship profoundly. Thus, it is important that I acknowledge the limitations introduced by my positionality as a white, cisgender, heterosexual woman.

Critical Theory "engages in ideologically oriented investigation, examining current thought and social structures (Pickard, 2013, p. 11)". Feminism is a Critical Theory approach to interpretivism. I agree with Webb and Young (2005) that using a feminist approach to research gives rich insights into women's experiences of working in the tech industry. Thus, I used an intersectional liberal feminist lens in my research. Critical characteristics of feminist research are that it is conducted for women and not on women and that it has the ultimate goal of improved representation and social change (Webb and Young, 2005).

3.3. Research Methods

A key element of feminist research is that researchers can use a wide variety of methods and techniques (Webb and Young, 2005). The first step was understanding and documenting the gender inequality in the tech industry. I performed an extensive literature review to identify important factors that might influence women's persistence and advancement in careers in the technology sector. The literature review explores liberal and intersectional feminism as this research is informed by intersectional liberal feminism. I identified three major themes, namely: individual experience, culture, and career progression.

The knowledge acquired through the literature review informed the design and development of the Binary in the Binary project web application. I experimented with web technologies to

develop a proof-of-concept tool for a major study on gender representation in the tech industry. The Binary in the Binary project is a PostgreSQL database-driven web application written in PHP and JavaScript and run on the open-source Apache HTTP Server.

The study is quantitative in nature because the data on people's attitudes are gathered indirectly through a survey on the Binary in the Binary web application. Data collected by quantitative methods are predetermined (Rohrer, 2022). In this study, the users select an answer to the question "Who will be in a more senior position in the tech industry in 5 years?" by clicking on an image of a person.

This is attitudinal research because the aim of the web application is to collect data on people's gendered perceptions about career progression in the tech industry and to ascertain if there is an improvement over time. Having numerical data about people's attitudes will stress the importance of prioritising the empowerment of women in tech. Additionally, the survey results will shed light on how ethnicity affects career progression. This is important because although there is lack of data about women overall, there is significantly less data on women of colour (Criado Perez, 2019).

Due to the nature of attitudinal research, the study is "limited by what people are aware of and willing to report (Rohrer, 2022)." However, because the survey is anonymous, respondents should not be concerned about any consequences to their answers.

3.4. Development Approach

Utilising a software development model improves the development process as well as the software quality (Stoica, Mircea and Ghilic-Micu, 2013). I followed an agile development

model loosely while coding the Binary in the Binary web application. This was preferable to an inflexible, traditional predictive approach, such as the Waterfall method. Adopting an agile approach enables a nimble, fast, yet flexible software development process (Abrahamsson et al., 2017). Furthermore, increased agility results in decreased development time (Stoica, Mircea and Ghilic-Micu, 2013). This was beneficial because of the tight project timeline.

Unlike a traditional approach an agile method has the advantage of adaptability, making it possible to respond to change and make late specification changes (Abrahamsson et al., 2017; Beck et al., 2001). This was crucial while developing the Binary in the Binary web application because new requirements became apparent as the project progressed. For example, initially, I did not store the test date but later realized it was necessary to compare the project results over time.

When implementing an agile methodology, working software is the primary measure of progress (Beck et al., 2001). Therefore, from the beginning of the development process, I focused on producing working software rather than writing comprehensive documentation (Abrahamsson et al., 2017). Additionally, I tested the web application at frequent intervals during the development lifecycle.

According to Beck et al. (2001), an agile approach is enhanced by "[c]ontinuous attention to technical excellence and good design" (p. 3). During development, I focused on ensuring the code was as simple but as technically advanced as possible (Abrahamsson et al., 2017). With this in mind, I developed the web application according to the MVC design pattern (see Figure 19). I discuss this in detail in Section 4.3. I also provide detailed comments and explanations in my code.

3.5. Justification

Research about women's experiences in the male-dominated tech industry is crucial because as Sandberg (2013) explains, "knowing that things could be worse should not stop us from trying to make them better (p. 5)."

This research is useful for women entering and participating in the tech industry. To empower women in tech, they should be fully aware of the difficulties they may face during their careers. By being knowledgeable, women will be in a position to identify and combat factors that prevent their career advancement. This in turn, will enable more women to persist in this male-dominated industry.

This study is also important to educate the men who comprise over three quarters of the total employment in the tech industry and hold 91 percent of the leadership positions (Hamer, 2019). Men can play a crucial role in changing this inequality in the industry by understanding the issues women face and making a conscious effort to remedy the situation. For example, knowing that women do more of the undervalued work, men may be encouraged to share these responsibilities equally.

If both men and women in leadership positions are educated about women's experiences in the tech industry, they may change the current culture that prevents women from progressing. Additionally, this research will encourage women who hold leadership positions to support those who work in the lower ranks.

The Binary in the Binary project aims to collect the data that will uncover and rectify the "old injustices" women in tech face (Criado Perez, 2019, p. 107). Organizations in the industry can

use this research and the data from the web application survey, to identify areas that need attention and make improvements to ensure an inclusive and diverse workforce.

4. The Binary in the Binary – Project Proposal

The Binary in the Binary project is a proposal for a major study about women in the tech industry. The Binary in the Binary web application is a research tool used to test people's perceptions about how gender affects career progression in the tech industry. I developed this web application as a proof of concept. If implemented, it is suggested that the study would be repeated annually to identify recent trends and to track whether respondents' opinions have shifted. This would be particularly interesting if organizations addressed the obstacles women in tech face (discussed in the Literature Review, Section 2). Furthermore, the Binary in the Binary web application stores respondent demographics, which will be used to ascertain if the respondents' background affects their responses.

Binary, in the context of gender, refers to the classification of people into opposing genders. Binary, in the context of tech, refers to binary code. Thus, the project name, the Binary in the Binary, refers to gender in the tech industry.

I developed the Binary in the Binary web application rather than creating the survey using a pre-developed survey tool, such as SurveyMonkey. This was important to me because I wanted to incorporate my interest in gender parity in the tech industry, a topic that I am passionate about, with my coding skills to develop a project proposal. Furthermore, I wanted the project about women in tech to be developed by a woman in tech.

4.1. User Interface and User Experience Design

A critical aspect of the project was designing and implementing a thought-through and simple UI and UX. I created a style guide and detailed user interface mock-ups for both the desktop and mobile versions to follow during development.

4.1.1. Style Guide

A style guide is a resource that contains details related to a product's UI and ensures continuity throughout the project (Silveira, 2021). This style guide (see Figure 3) provides the Binary in the Binary primary and secondary logos, colour scheme, and font. Criado Perez's (2019) book, *Invisible Women*, inspired the Binary in the Binary web application colour scheme.

The Binary in the Binary logo is the binary conversion of the word "equal". This is appropriate, because the ultimate goal of the project is social change and increased gender representation in the tech industry.

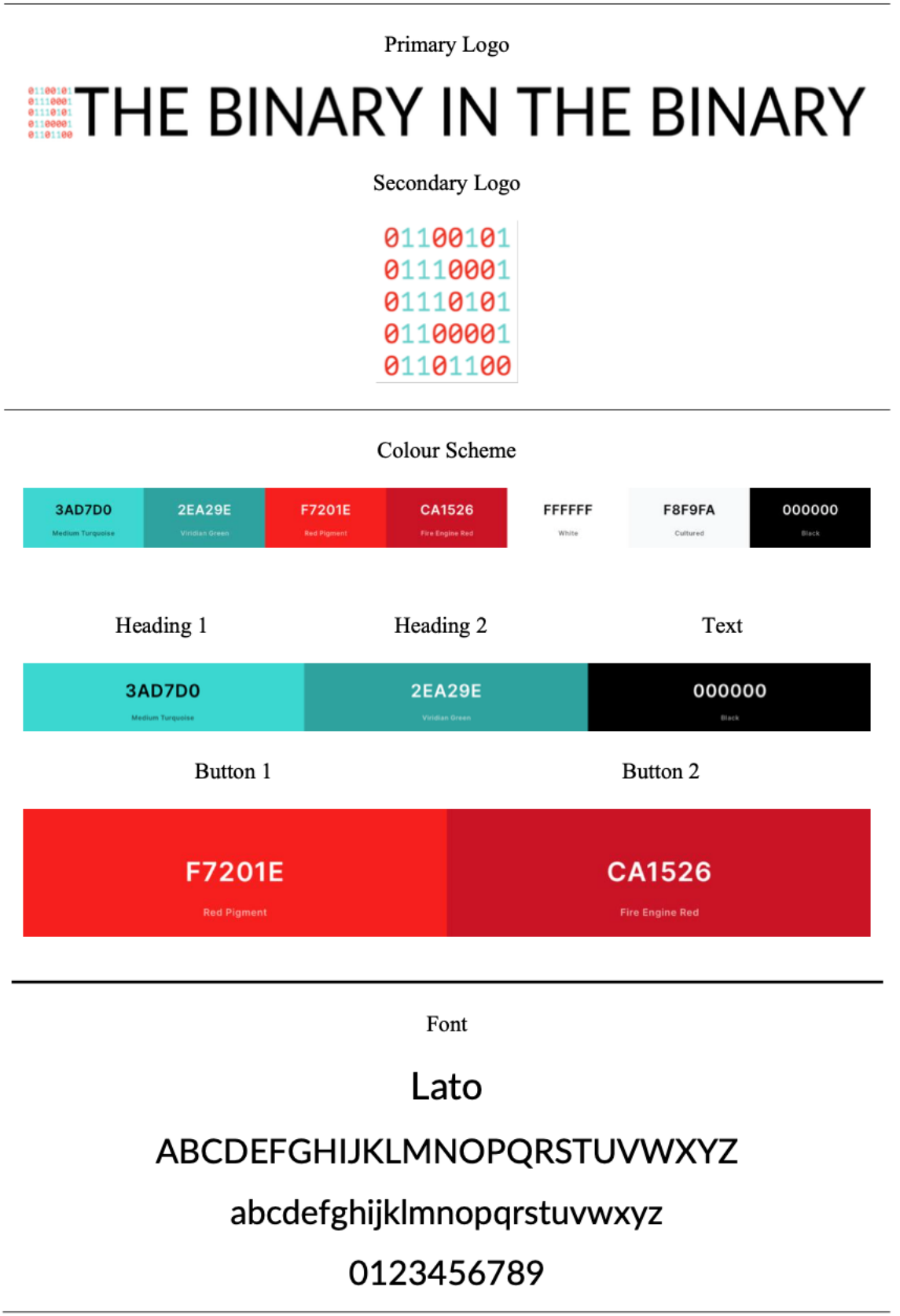

Figure 3: The Binary in the Binary Project Style Guide

4.1.2. Wireframes

Wireframes, a crucial part of the design process, provide a visual understanding of key web pages, the elements, and the user journey (Experience UX, n.d.). As the Binary in the Binary web application is responsive, I designed both desktop and mobile wireframes.

All the pages have a header and a footer. The header contains the project secondary logo (see Figure 3) on the left of the page and a menu bar on the right. The menu bar has a Take Test link that directs the user to the Consent page (Figure 4). Additionally, the menu bar has a profile icon that opens a dropdown menu if the user clicks on it. As seen in Figure 4, if there is no user logged in, then the dropdown has a Login button and the message: Login for researcher access. In the mobile version, the menu button contains all the menu bar components (see Figure 4). The footer displays the project name: The Binary in the Binary.

The Consent page, Figure 4, is the main landing page for the Binary in the Binary web application. This page invites the respondent to participate in the study. It details what data is collected and how it is stored and asks the respondent for consent to proceed. To continue, the user must click the I consent button.

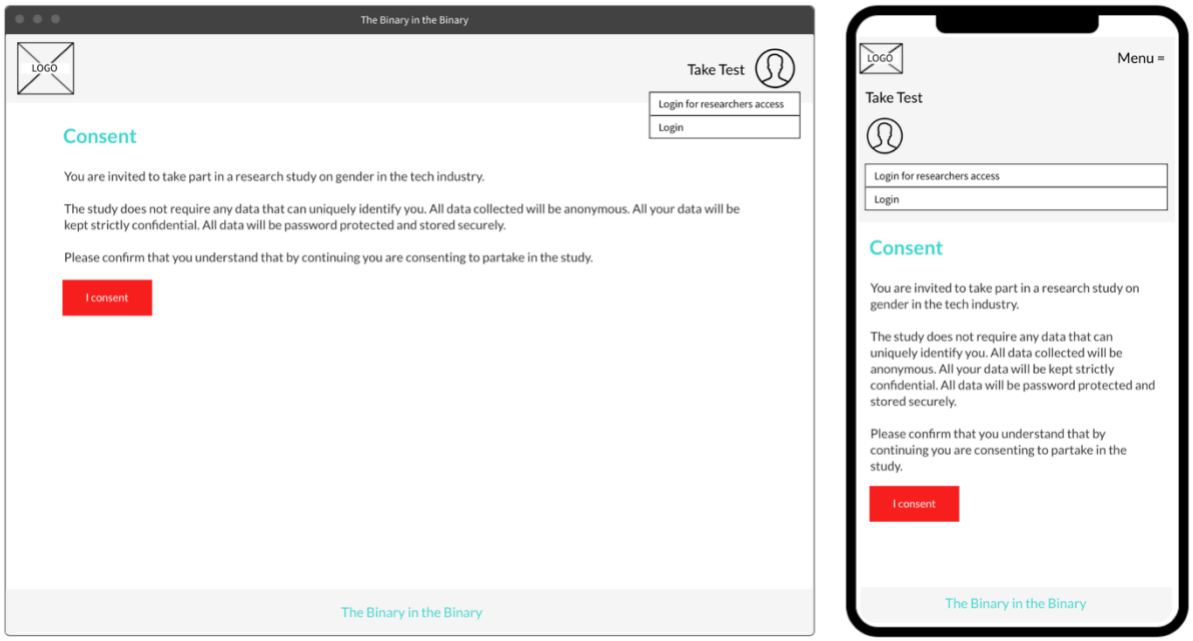

Figure 4: The Binary in the Binary Desktop and Mobile Consent Page with Dropdown Menu

Once the respondent has consented, they are redirected to the Respondent Demographics page, see Figure 5. On this page the user selects the appropriate gender, ethnicity, year of birth, and country of residence from dropdown boxes.

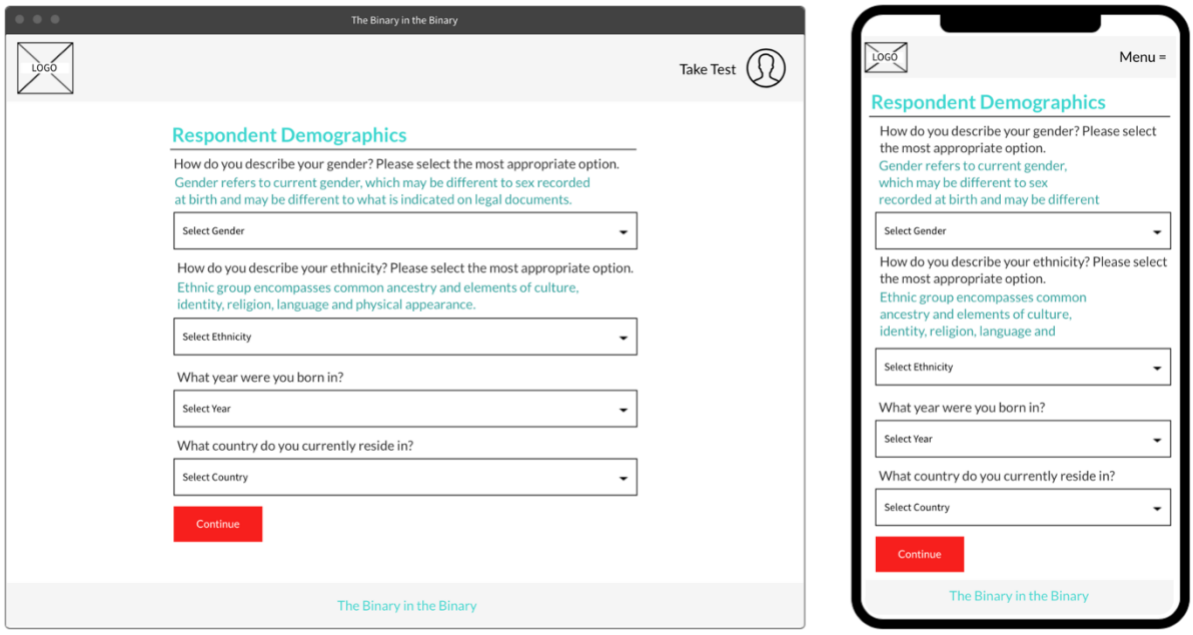

Figure 5: The Binary in the Binary Desktop and Mobile Respondent Demographics Page

If the respondent clicks the Continue button before answering all the demographic questions, an error message displays asking the user to answer all the questions (see Figure 6).

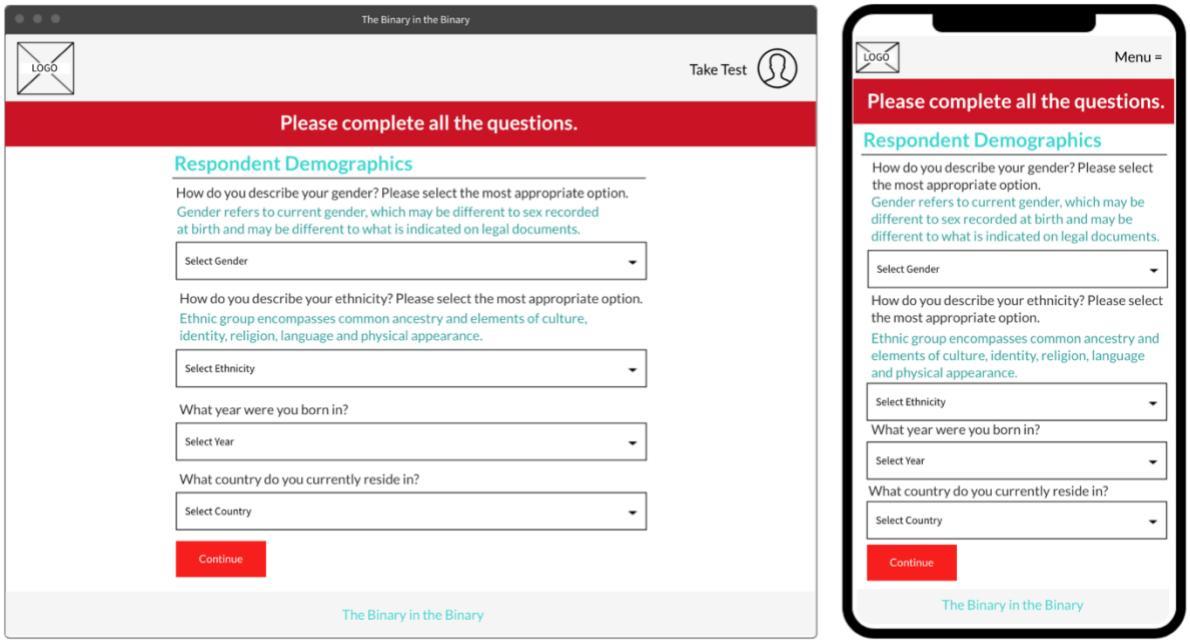

Figure 6: The Binary in the Binary Desktop and Mobile Respondent Demographics Page with Error Message

Alternatively, if the respondent has entered all the demographics and clicks the Continue button, they are redirected to the Response page (see Figure 7). This page displays two images and asks the respondent who will be in a more senior position in the tech industry in five years. The respondent answers the question by clicking on the image. This same test is repeated with images of different people with varying genders and ethnicities until the respondent answers all the questions.

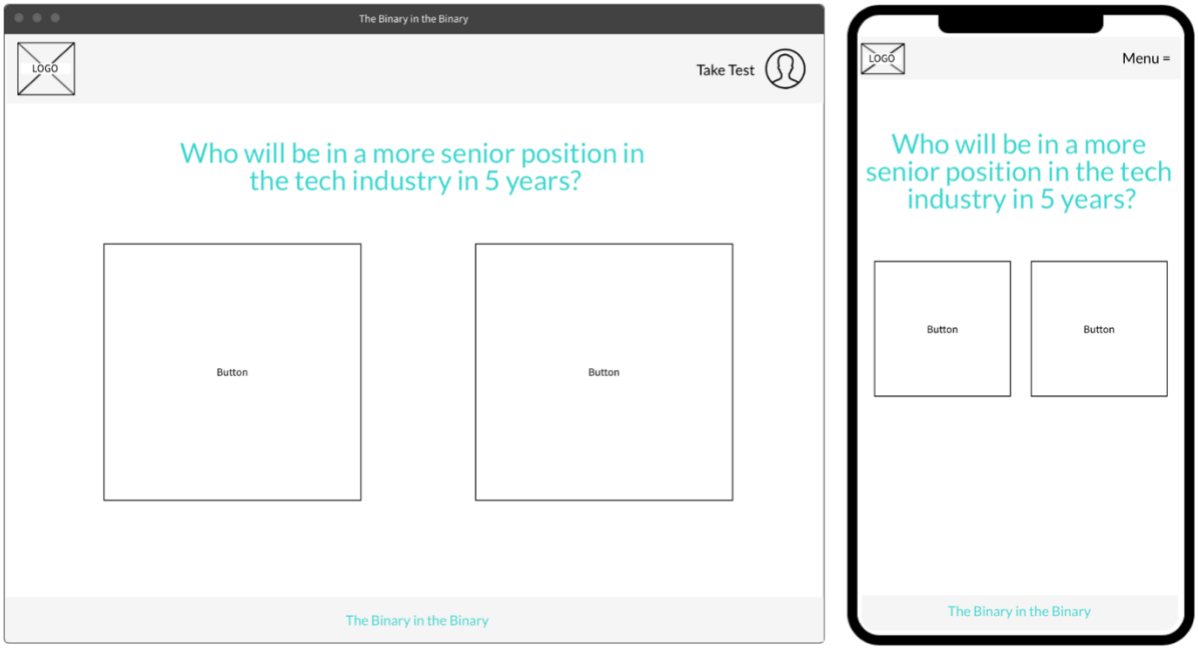

Figure 7: The Binary in the Binary Desktop and Mobile Response Page

Once the respondent answers the last question, the Thanks page is displayed, as seen in Figure 8. This page contains a thank you message and the project primary logo (see in Figure 3).

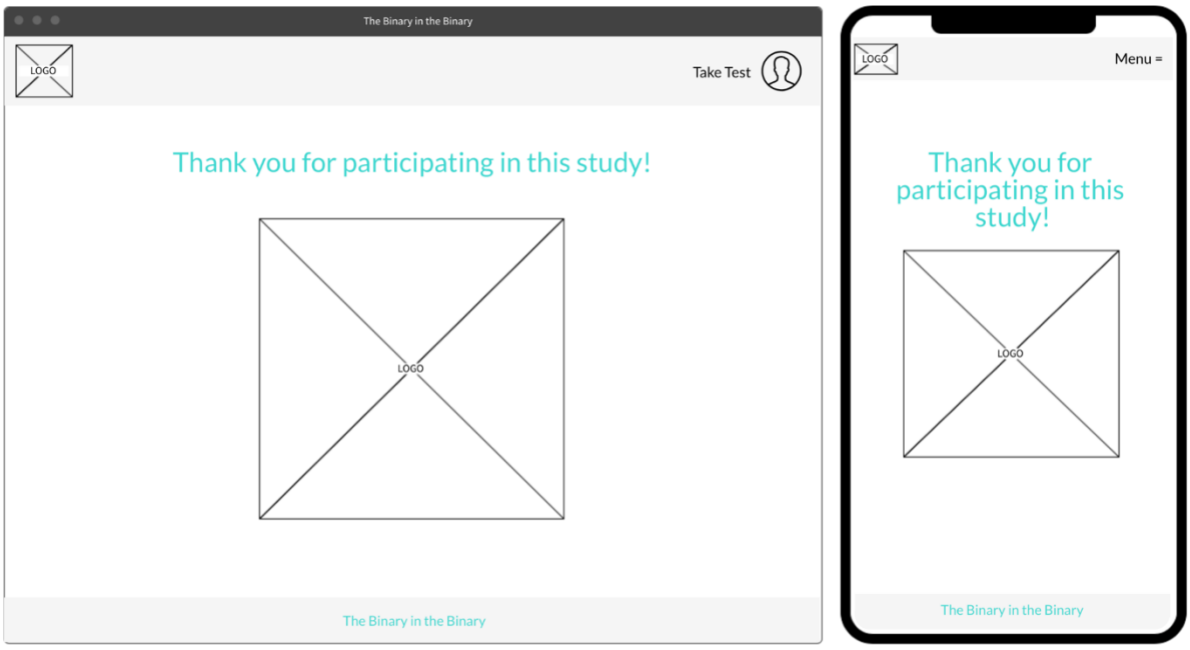

Figure 8: The Binary in the Binary Desktop and Mobile "Thanks" Page

If the user clicks the Login button on the dropdown menu (see Figure 4), they are redirected to the Login page (Figure 9). This page handles the authentication of users with usernames and passwords. If the user enters an invalid username or password, an error message displays, as seen in Figure 10.

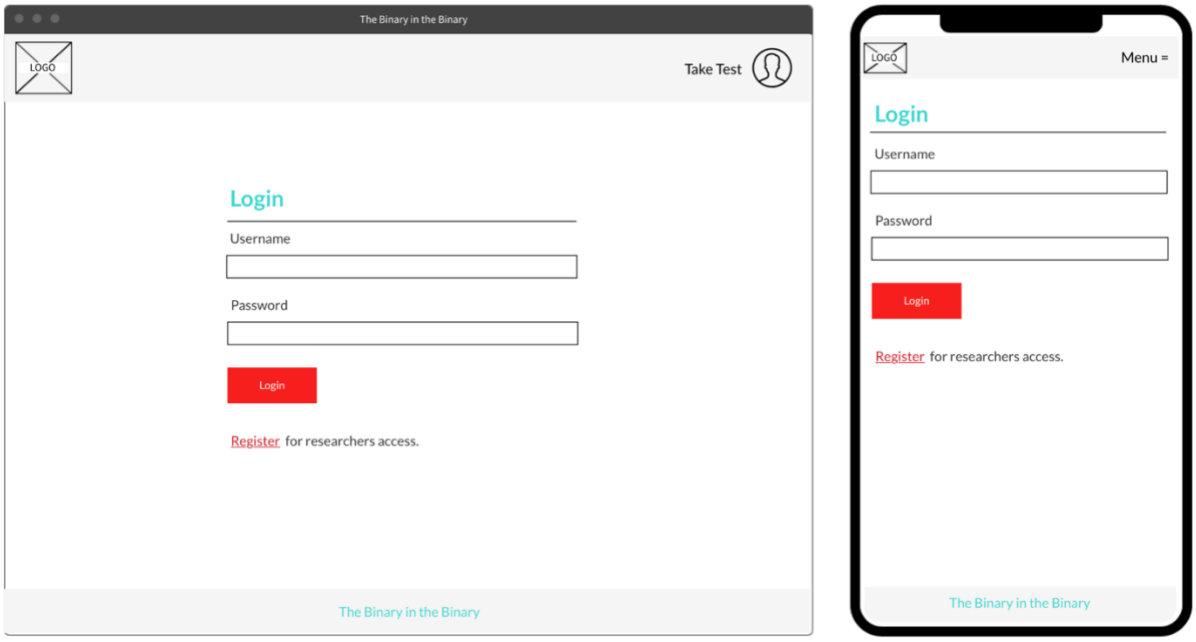

Figure 9: The Binary in the Binary Desktop and Mobile Login Page

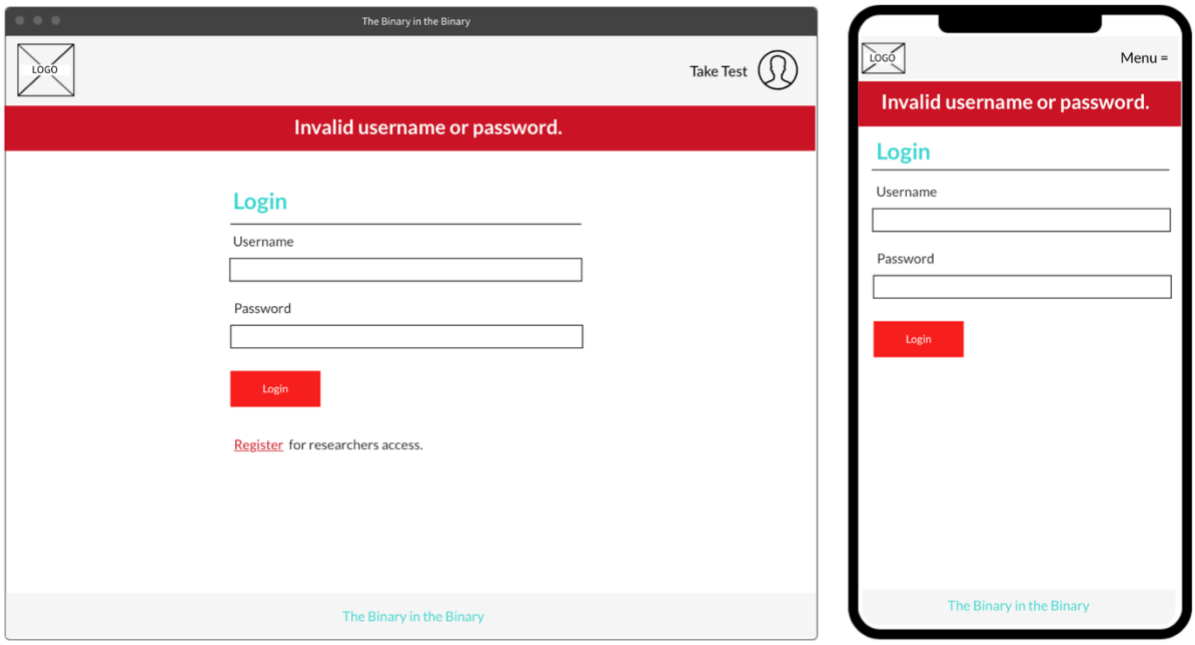

Figure 10: The Binary in the Binary Desktop and Mobile Login Page with Error Message

There are two user groups: admin and researcher. If a user with researcher or administrative privileges logs in, they are redirected to the Results page, see Figure 11. The Results page contains a table with respondent demographics and survey responses. However, if the user does not have an assigned user group, they cannot view the results and are re-directed to the Failure page (see Figure 12), which provides an explanation and a Log Out button. If the user clicks the Log Out button, they are redirected to the Login page (see Figure 9). Additionally, as seen in Figure 12, the dropdown menu indicates the logged-in user, a button to the Results page (which will redirect to the Failure page in Figure 12) and a Log Out button.

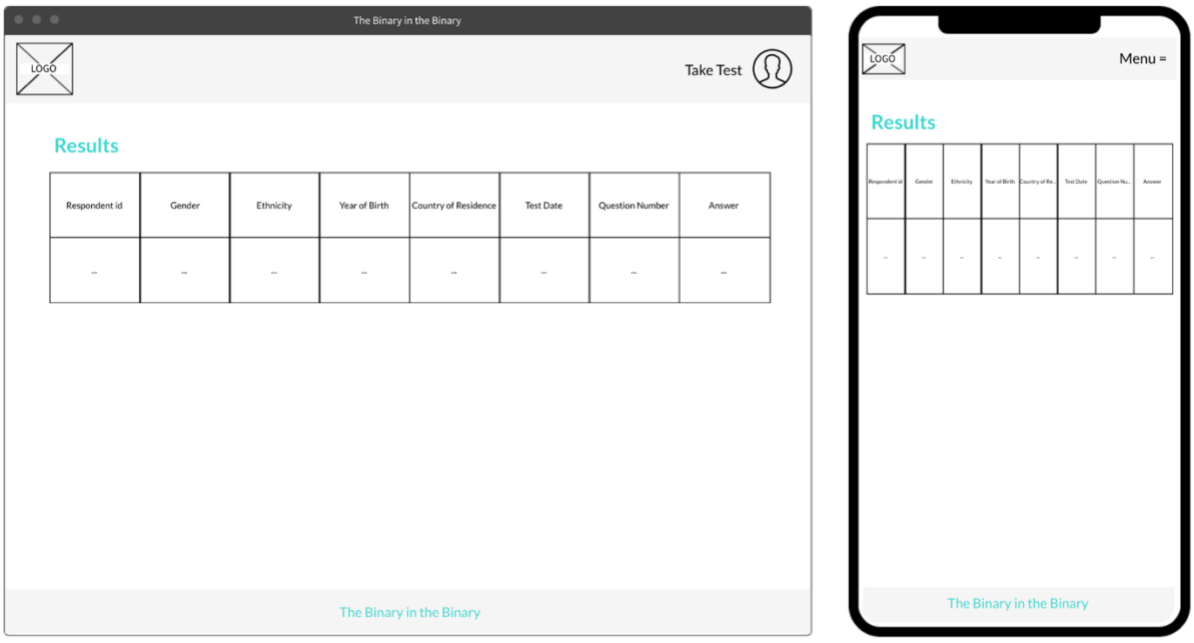

Figure 11: The Binary in the Binary Desktop and Mobile Results Page

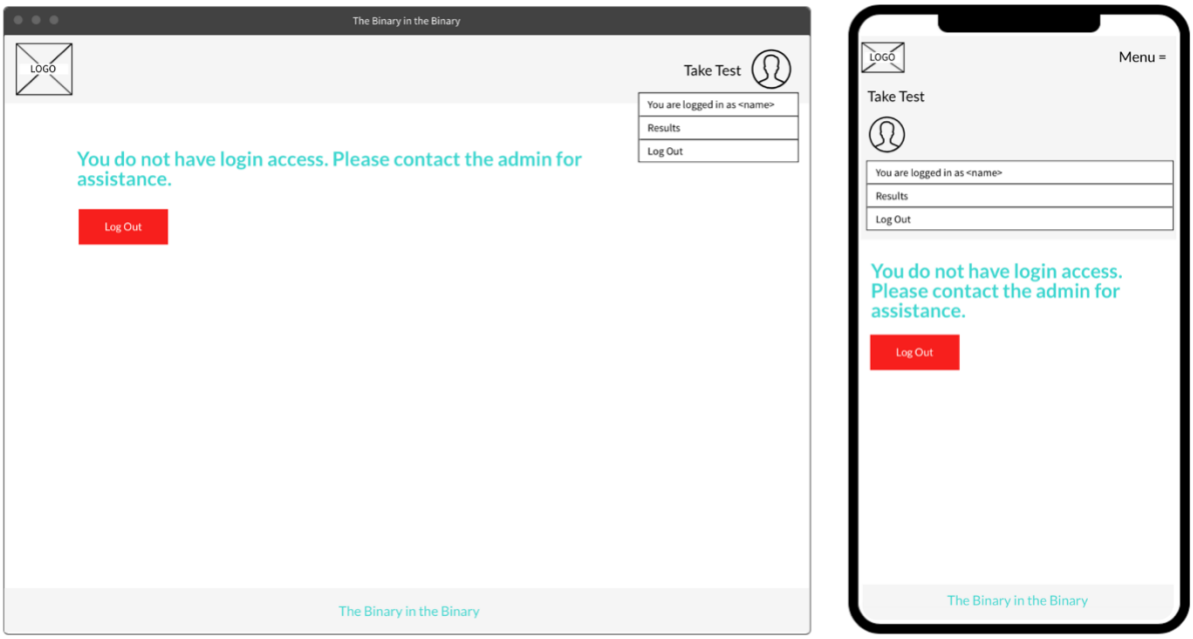

Figure 12: The Binary in the Binary Desktop and Mobile Failure Page

If the logged-in user is a researcher, the dropdown menu features a message indicating who the logged-on user is and that they have researchers' privileges, a link to the Results page, and a Log Out button, see Figure 13.

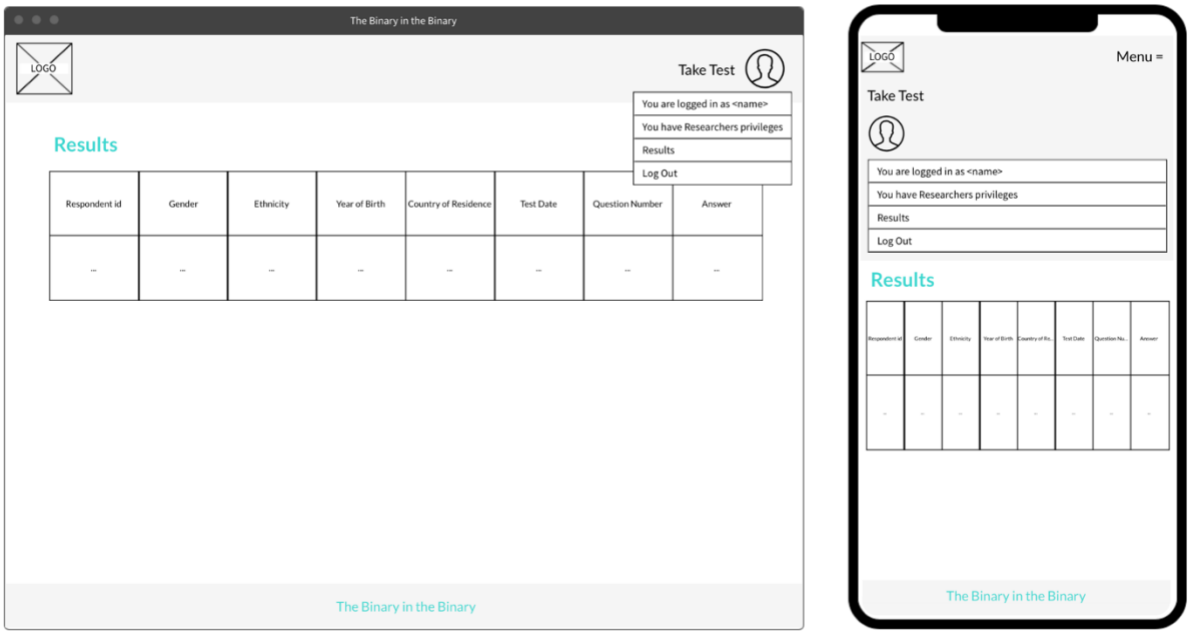

Figure 13: The Binary in the Binary Desktop and Mobile Researchers' Dropdown Menu

If the logged-in user is an administrator, the dropdown menu contains a message indicating who the logged-on user is and that they have admins' privileges, a link to the Users page, a link to the Results page, and a Log Out button, see Figure 14.

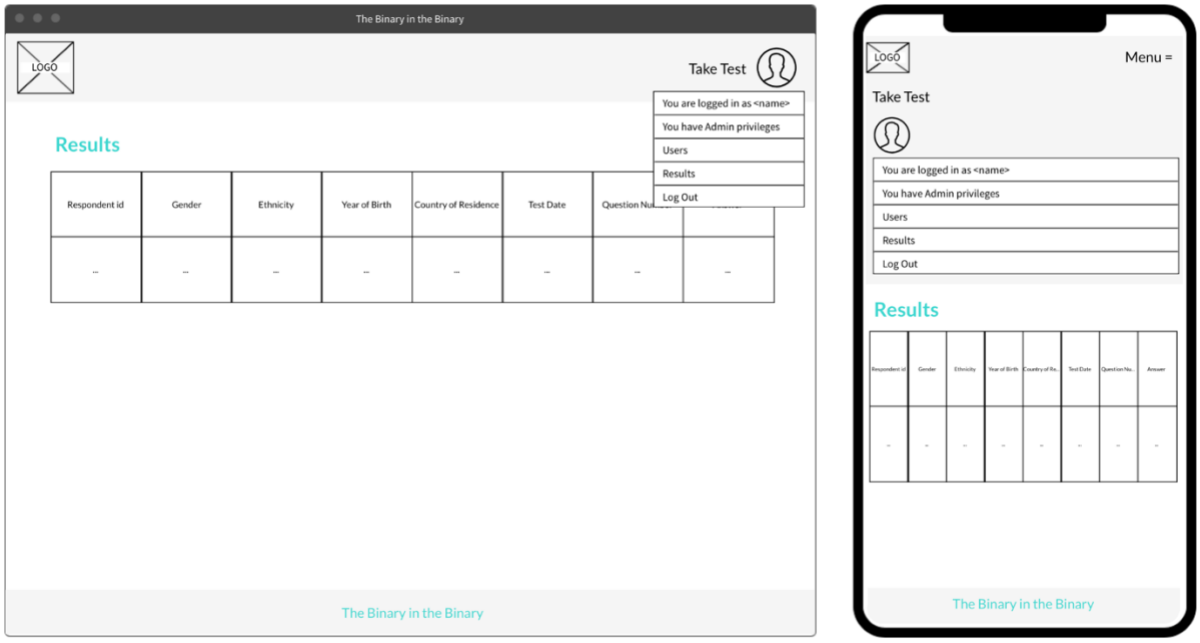

Figure 14: The Binary in the Binary Desktop and Mobile Admins' Dropdown Menu

If the administrator clicks the Users button on the dropdown menu (see Figure 14), they are redirected to the Users page, see Figure 15. This page lists the users and their associated user group. Each user in the list has a Remove button and an Edit button. The admin clicks the Remove button to delete a user from the database. If the user clicks the Edit button, then the user is redirected to the User Editor page (Figure 16).

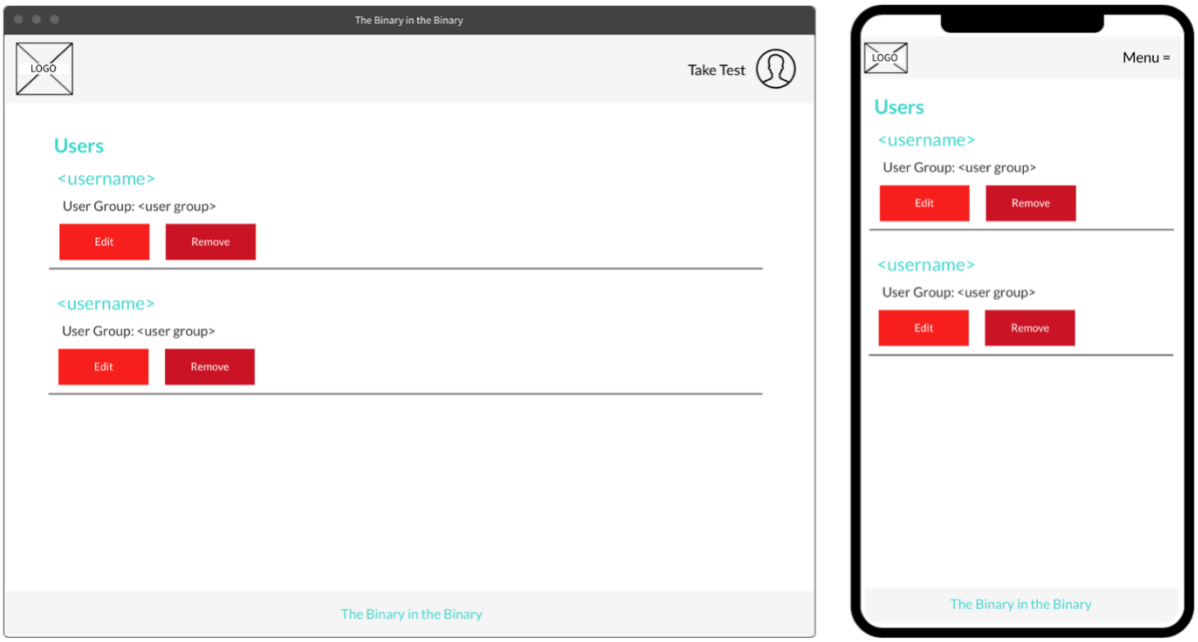

Figure 15: The Binary in the Binary Desktop and Mobile Users Page

On the User Editor page (Figure 16), the administrator can assign a user group to a user. The user clicks the Save button to save the change and gets redirected to the Users page (Figure 15).

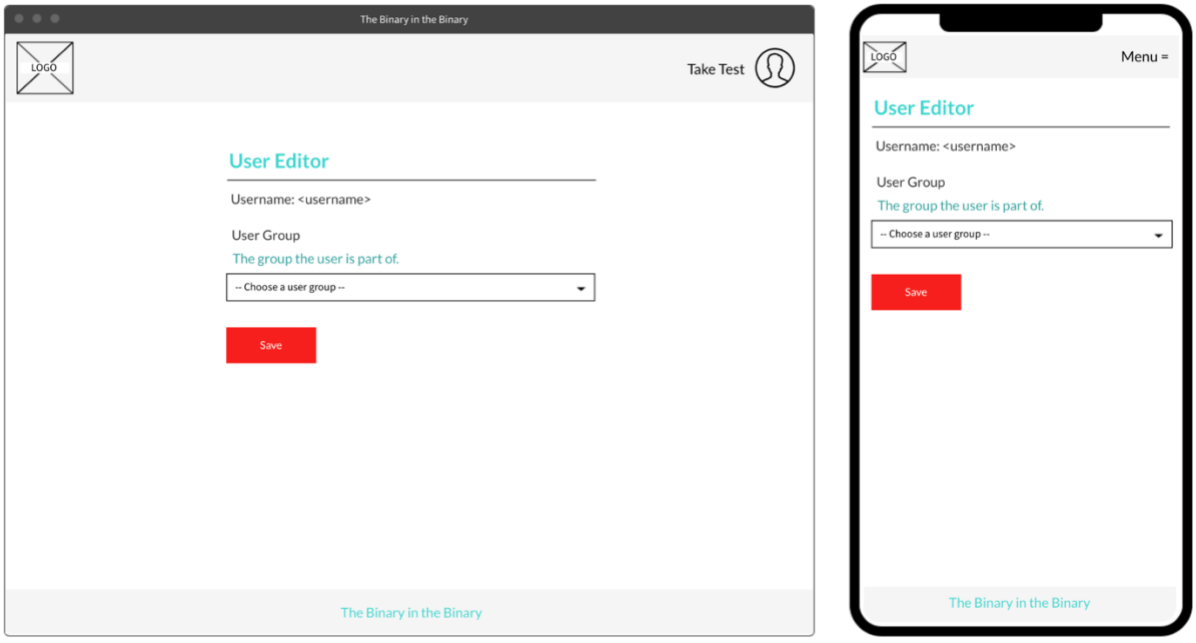

Figure 16: The Binary in the Binary Desktop and Mobile User Editor Page

The registration process creates records of the users of the web application. The user clicks the Register button on the Login page (see Figure 9) to register and is redirected to the Registration page, as seen in Figure 17. The user enters their username (which must be unique), a password (twice for validation purposes), and the current year (for anti-spam purposes). If the user enters a username that is already taken, the passwords do not match, or the incorrect year, an error message displays (Figure 18), and the Registration page (Figure 17) re-opens. Alternatively, if the registration is successful, the user is redirected to the Failure page (Figure 12). This is because the administrator has not validated the new user by assigning that user to a user group.

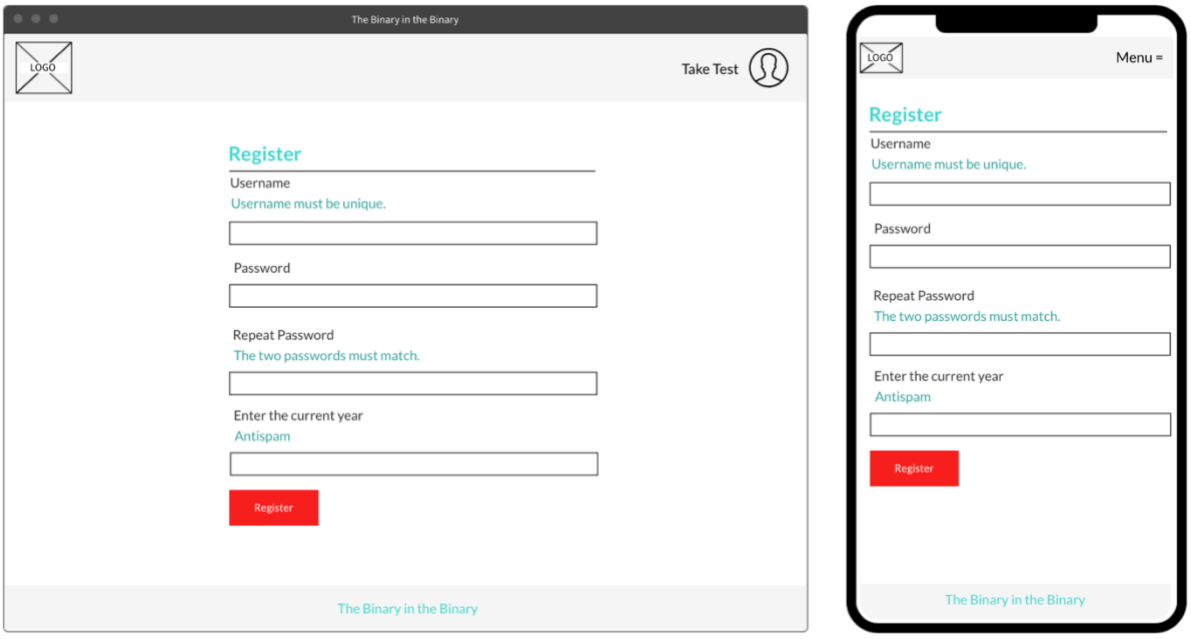

Figure 17: The Binary in the Binary Desktop and Mobile Registration Page

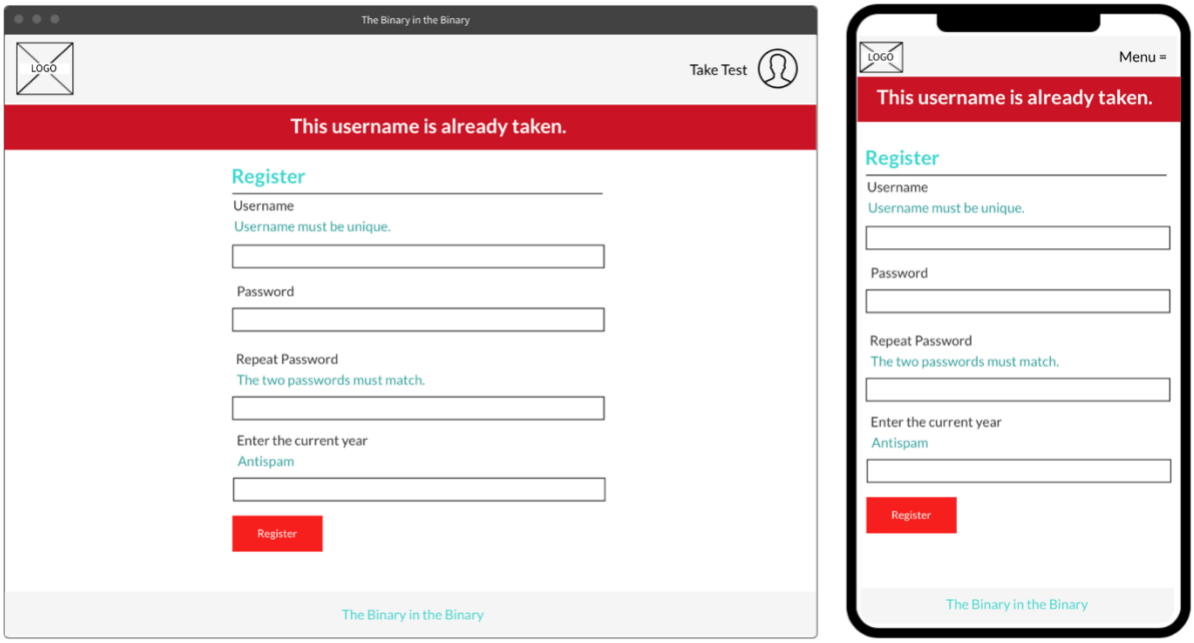

Figure 18: The Binary in the Binary Desktop and Mobile Registration with Error Message

The style guide (Figure 3) and the wireframes (Figure 4 to Figure 18) were instrumental while developing the Binary in the Binary web application.

4.2. The Binary in the Binary Web Application Login Details

Primary URL: http://wwwdis.ucl.ac.uk/~uczcjth/Dissertation/cms/consent

Three logins are required to see the full functionality of the Binary in the Binary web application.

The administrator has authorisation to all components of the web application. The administrators are responsible for user management. An administrator is assigned to the "Admin" user group.

Administrator Login Details

Username: BITBAdmin

Password: Admin@BITB

A researcher is a user that the administrator has assigned to the "Researcher" user group. A researcher can view the survey results on the Results page.

Researcher Login Details

Username: SherylSandberg

Password: LeanInSheryl

A visitor is a user that an administrator has not authorised by assigning a user group. Visitors are only granted basic privileges and have the same access as a user without login details. Visitors are redirected to the Failure page when they log on.

Visitor Login Details

Username: MGates

Password: MomentOfLift

4.3. Development

The Binary in the Binary is a database-driven web application written in PHP and JavaScript and runs on the open-source Apache HTTP Server.

I followed the Separation of Concerns (SoC) design principle during the development of the Binary in the Binary web application. According to SoC, separate parts of the software solve different components of a problem (De Win et al., 2002). More specifically, I used the popular MVC design pattern, in which code is developed in three distinct layers, each of which handle a specific aspect of the application (see Figure 19).

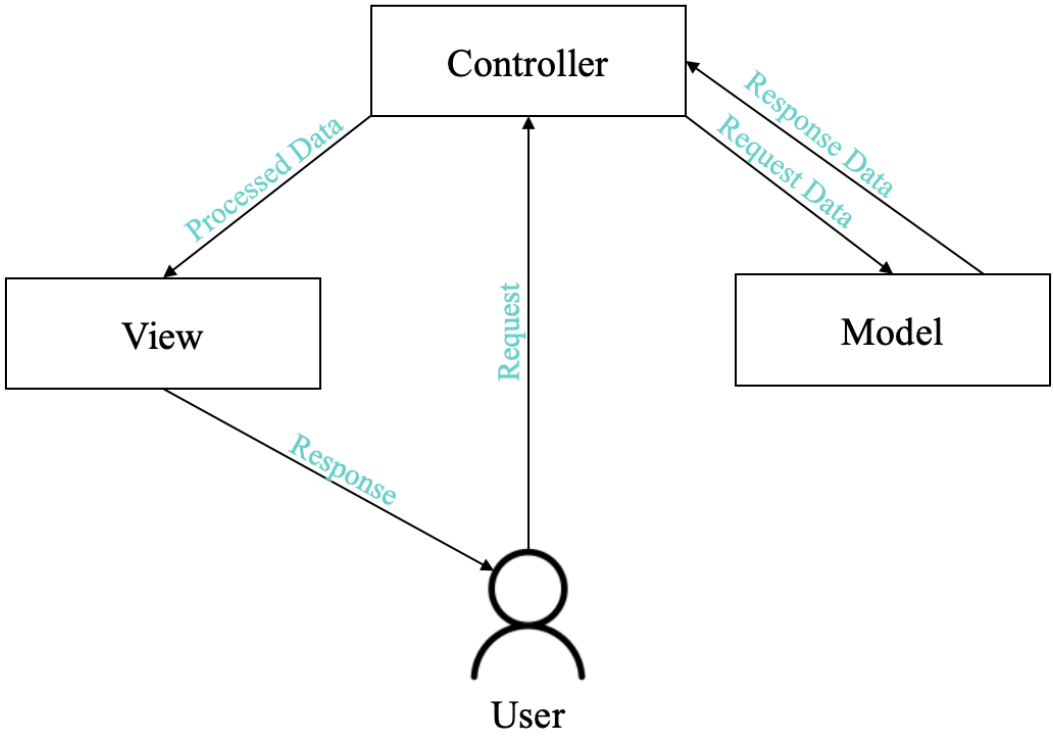

Figure 19: Diagram Explaining the Model View Controller (MVC) Design Pattern

PHP supports object-oriented programming (OOP). This is important because OOP principles (abstraction, polymorphism, inheritance, and encapsulation) are key to implementing a MVC

design pattern. OOP is a programming paradigm where code is layered in simple, re-usable classes to avoid unnecessary code duplication (Doherty, 2020). Additionally, OOP is beneficial because it ensures that programmes are maintainable and scalable. This is important, because if implemented, the Binary in the Binary web project would expand.

The .htaccess file is the Apache configuration that rewrites the traffic to the index.php file. This enables clean URL support in PHP. The file routes all traffic through the index.php unless the request is for a file that exists in the requested location, then the Apache web server handles the request directly.

The index.php file is the main application file that loads the necessary classes to execute the code. autoloadFunction is responsible for file inclusion. The function replaces backslashes (\) and slashes (/) within the class name with the directory separator for the operating system, which is a pre-defined constant provided by the PHP DIRECTORY_SEPARATOR function. This is important because it makes the application agnostic to operating systems. Additionally, to simplify the application and make the MVC design more apparent, the autoloadFunction uses preg_match to check if the class name ends in Controller. If it does, the autoloader will look for the associated file in the controller folder. Otherwise, it will look in the model folder.

The session is started in the index.php file, which allows users to access the session storage. The session_error_handling function handles session misconfigurations and errors. Next, the autoloading function is registered. Then the configuration constants containing the URL path are defined. The connect method from the Db class is used to establish a connection to the database. Next, a RouterController object is instantiated, which processes the requested URL

retrieved using $ _SERVER['REQUEST_URI']. Finally, the RouterController object renders the appropriate view.

Next, I discuss the model, view, and controller layers in detail.

4.3.1. The Model Layer

The model layer contains the data and the logic that alters the data in response to user interaction (Leff and Rayfield, 2001). The Binary in the Binary web application retrieves all the essential content dynamically. The model layer consists of the database and the code that allows one to interact with the data.

4.3.1.1. The Database

The Binary in the Binary uses PostgreSQL as the primary database. PostgreSQL is a relational database management system with SQL compliance (Amazon Web Services, 2022). I designed the database to be as simple and normalised as possible. This is important to ensure that the database can change and adapt as the project evolves. There are three tables: Users, Respondents, and Responses. See the database schema in Figure 20.

The Users table stores data about the users (name, password, and user group) and is used for user authentication and authorisation. The Respondents table stores respondent demographics, including gender, ethnicity, year of birth, and country of residence. These demographics are valuable when investigating and interpreting the background factors that influence the respondent's choices. The Responses table stores each respondent's answers to the survey questions and the test date.

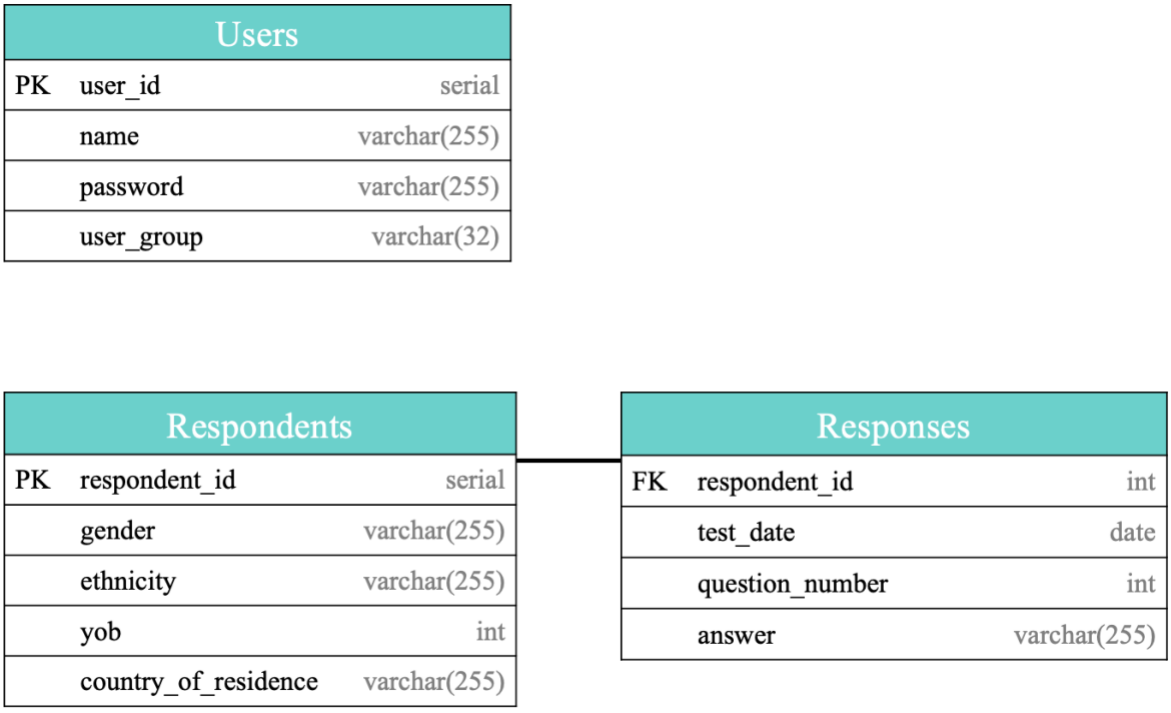

Figure 20: The Binary in the Binary Project Database Schema

The following relational models map the tables, with the primary keys underlined and foreign keys in italics:

USERS (user_id, name, password, user_group)

RESPONDENTS (respondent_id, gender, ethnicity, yob, country_of_residence)

RESPONSES (*respondent_id*, test_date, question_number, answer)

respondent_id is a foreign key that refers to respondent_id in the RESPONDENTS relation, with NULL not allowed.

4.3.1.2. The Code

The Db class is the database wrapper that provides low-level functionality to interact with the PostgreSQL database described in the previous section (4.3.1.1.). The static $connection property stores a PDO database connection and is available during the application runtime. Db contains seven static methods: connect, queryAll, queryOne, query, insert, insertwReturn, and update. The connect method uses the credentials passed into the method to connect to the database. The queryAll method executes a query and returns all resulting rows as an array of associative arrays. The queryOne method executes a query and returns the first row of the result. The query method executes a query and returns the number of affected rows. The insert method inserts data from an associative array into the database as a new row. The insertwReturn method is similar to the insert method but returns the associated autogenerated respondent_id. Finally, the update method executes a SQL update using data passed into the method as an associative array.

The RespondentModel class comprises three methods. Firstly, the getRespondents method returns all the respondent details in the database ordered by the respondent_id. The getRespondent method returns a single respondent using the respondent_id passed into the method. Finally, the registerRespondent method saves the demographics of a new survey respondent using the inherited insertWReturn method from Db. This method returns the respondent_id to the Controller class.

The ResponseModel class contains two methods. The saveResponse method saves the respondent's answer to the survey in the database. The endTest method uses the session_destroy method to terminate the session and remove all the data stored in the session array.

The ResultsModel class contains the getResults method that returns all the survey results. This method executes a SQL statement that inner joins the Respondents table to the Responses table using the common respondent_id field.

The UserModel class contains all the methods responsible for managing the user accounts and for authentication and authorisation. The first method is computeHash, which generates a hashed password. This method is crucial as storing plaintext passwords in a database is unsafe because if the database is compromised, users' passwords are leaked. When registering new users, the register method uses the computeHash method. The register method also checks the entered password match and performs anti-spam verification. The login function logs a user into the web application and stores the user details in the session array. The logoff method destroys the session. The getUser method returns the user currently logged on and returns null if there is no user logged on. The isAdmin method verifies whether a user is an admin. Similarly, the isResearcher method verifies if the user is a researcher.

The UsersModel class contains four methods. The getUsers method uses the queryAll method inherited from Db to return all the users in the database. The getUser method returns a singular user from the database using the Db queryOne method. The updateUser method uses the update method in the Db class to update a user’s details. Finally, removeUser deletes a user from the database.

4.3.2. The View Layer

The view layer contains the templates used to present data to the user (Leff and Rayfield, 2001). One benefit of implementing an MVC design pattern is that the developer is able to change the user interface easily without changing any logic.

The layout file is the base HTML template for the Binary in the Binary web application. The layout file contains the HTML for the navigation bar, the alert messages banner, the main content, the footer, and the back-to-the-top button. When called by the user, the various component templates (consent, failure, login, register, respondent, responseone, responsetwo, responsethree, responsefour, responsefive, results, thanks, users, and userseditor) are placed within the main content space holder.

The View folder contains a CSS subfolder with the base style.css file and the specific views' CSS files. The layout file links to the style.css file that stylises the entire application. The style.css file implements Lato, the font for the Binary in the Binary web application.

The layout file also embeds the external JavaScript client-side scripts. The layout file embeds a script that adds the scroll to the top button on each page. Figure 25 shows this button in the bottom right corner of the screen. Additionally, the layout file embeds the front-end library fontawesome for icons, such as the login on the navigation bar.

The Binary in the Binary web application uses the Bootstrap frontend framework to ensure the web pages are responsive. This is important as the web application must be usable and aesthetically pleasing on devices of varying sizes. A responsive design should be (i) flexible, meaning that the page elements change size according to the viewport's width, and (ii) adjustable, meaning elements can be added or removed depending on the viewport's width. Figure 21 to Figure 49 show the desktop and mobile versions, and thus the responsiveness, of the Binary in the Binary web application.

The navigation bar dropdown menu changes dynamically, depending on if there is a logged-in user and if so, to which user group the user belongs. If no user is logged in, the dropdown menu shows a message and a login button (see Figure 21). Alternatively, if the logged-in user is a researcher, the dropdown menu includes the username, the user privileges, a link to the Results page, and a button to log out (see Figure 22). Finally, if the logged-in user is an admin, then the dropdown menu contains the username, the user privileges, a link to the Users page, a link to the Results page, and a button to log out (see Figure 23).

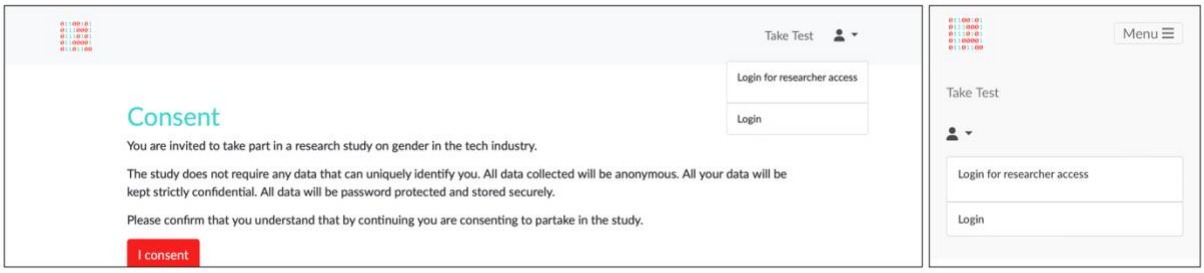

Figure 21: The Binary in the Binary Desktop and Mobile Navigation Bar

Figure 22: The Binary in the Binary Desktop and Mobile Navigation Bar with Researcher Logged In

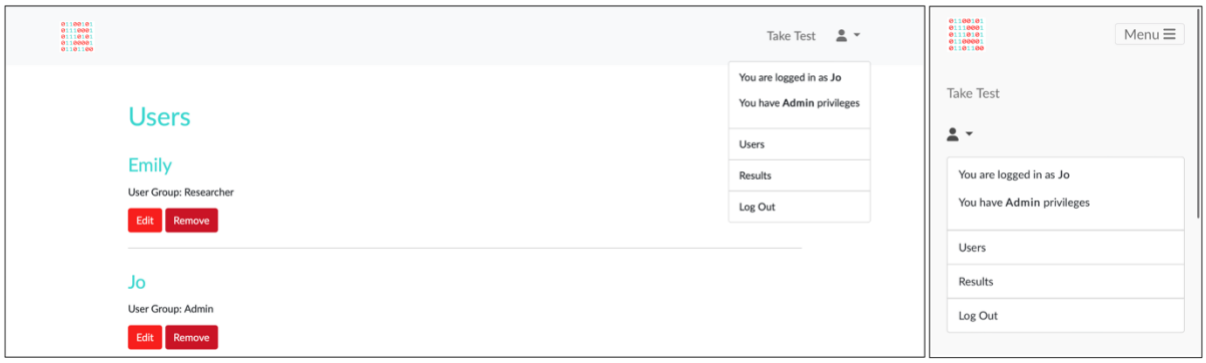

Figure 23: The Binary in the Binary Desktop and Mobile Navigation Bar with Admin Logged In

The login view is an HTML form that accepts the username and password of the user who wishes to log in. The login view uses the login.css stylesheet. Figure 24 shows the desktop and mobile Login pages. If the user enters an invalid username or password, the alert messages banner displays an error message informing the user (see Figure 25). When a user logs in successfully, the alert messages banner displays a success message (see Figure 26).

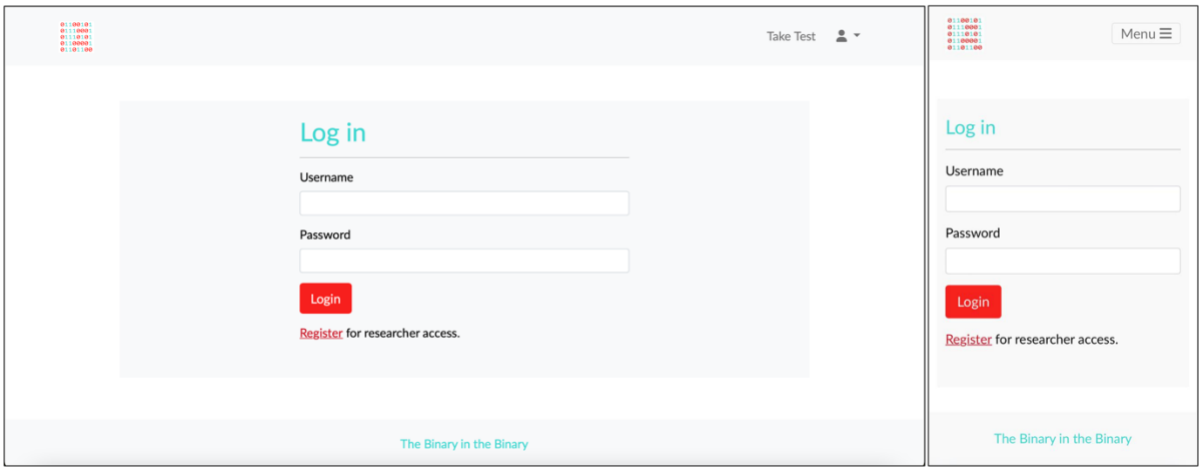

Figure 24: The Binary in the Binary Desktop and Mobile Login Page

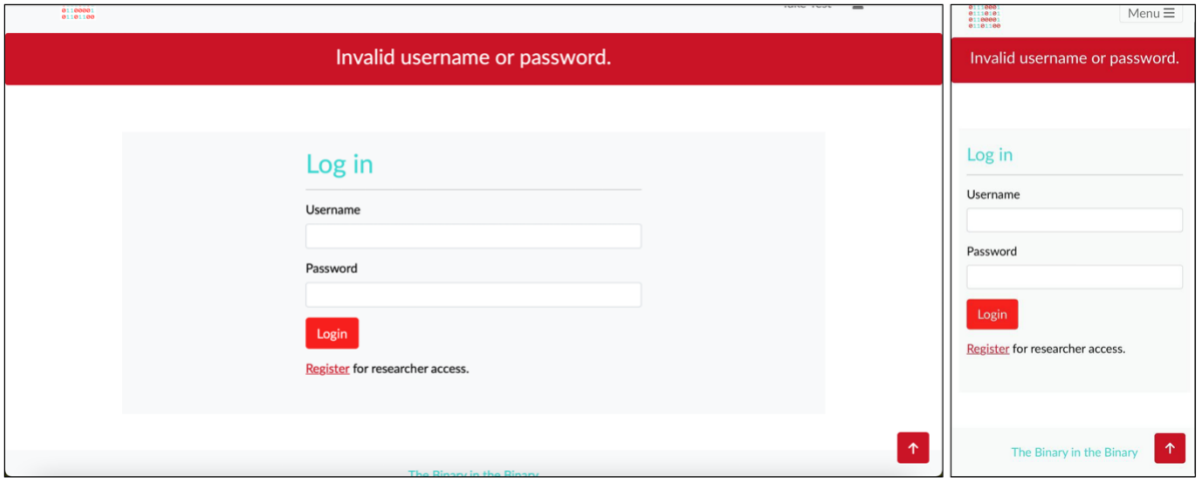

Figure 25: The Binary in the Binary Desktop and Mobile Login Page with Error Message

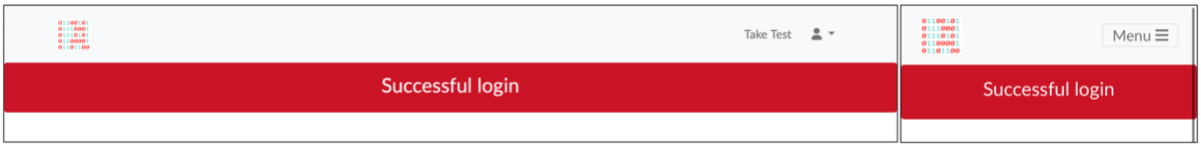

Figure 26: The Binary in the Binary Desktop and Mobile Login with Success Message

The register view contains a form where visitors can submit their details, including a username, password, password-repeat (to ensure the user has entered the correct password), and the current year (for anti-spam purposes). The register view uses the register.css stylesheet. Figure 27 shows the Register web page. The alert messages banner displays an error message informing the user if the username is not unique (see Figure 28), if the passwords do not match (see Figure 29), or if the anti-spam year is incorrect (see Figure 30).

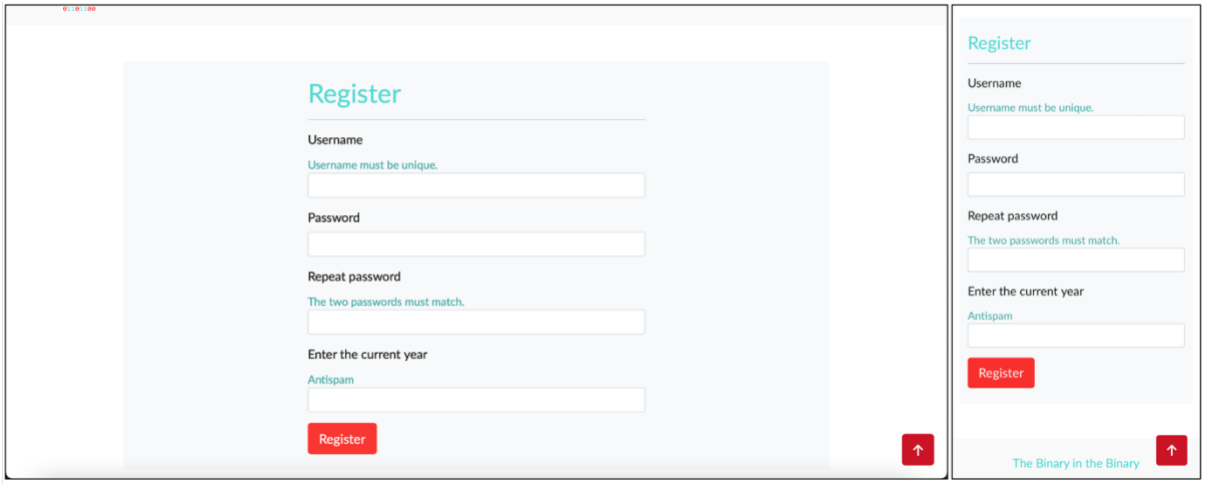

Figure 27: The Binary in the Binary Desktop and Mobile Register Page

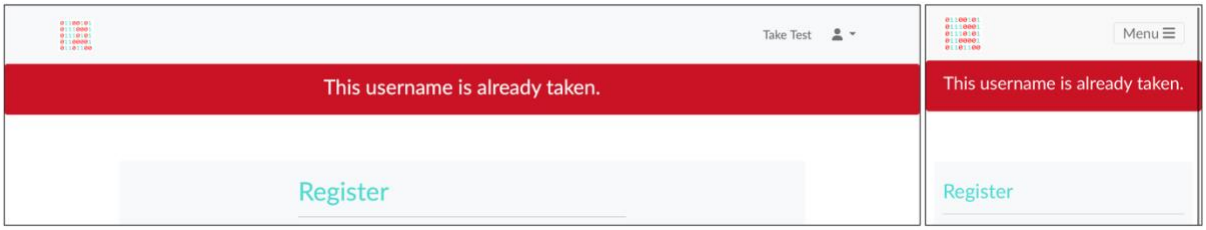

Figure 28: The Binary in the Binary Desktop and Mobile Register Page Username Not Unique Error

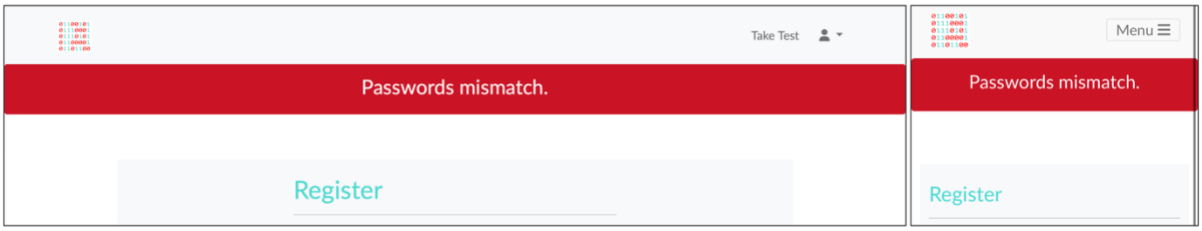

Figure 29: The Binary in the Binary Desktop and Mobile Register Page Password Mismatch Error

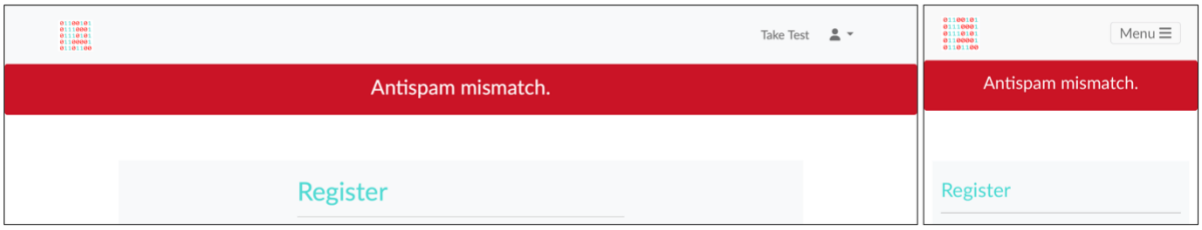

Figure 30: The Binary in the Binary Desktop and Mobile Register Page Anti-Spam Mismatch Error

The failure view is a simple HTML page with the Binary in the Binary primary logo (see Figure 3), a message informing the user that they do not have login access and a Log Out button. Figure 31 shows the Failure page. The failure view uses the failure.css stylesheet. This view is displayed when a user who is not an admin or researcher logs in. Additionally, a new user gets redirected to the Failure page after registration. If the user clicks the Log Out button, they get redirected to the Login page (see Figure 24).

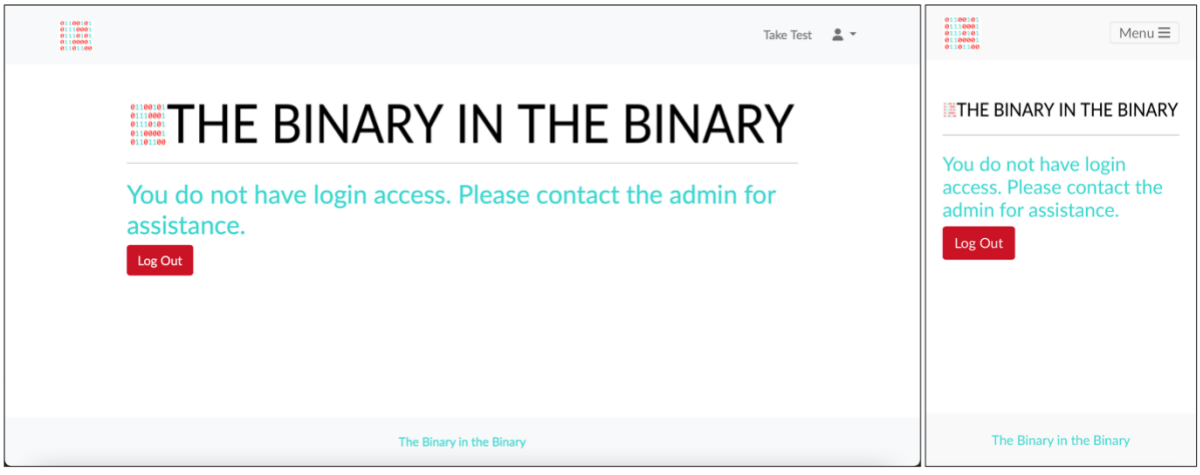

Figure 31: The Binary in the Binary Desktop and Mobile Failure Page

The results view, only viewable by admin and researchers, contains a table of the results acquired from the getResults method in the ResultsModel class. Figure 32 shows the Results page. This view uses the results.css stylesheet.

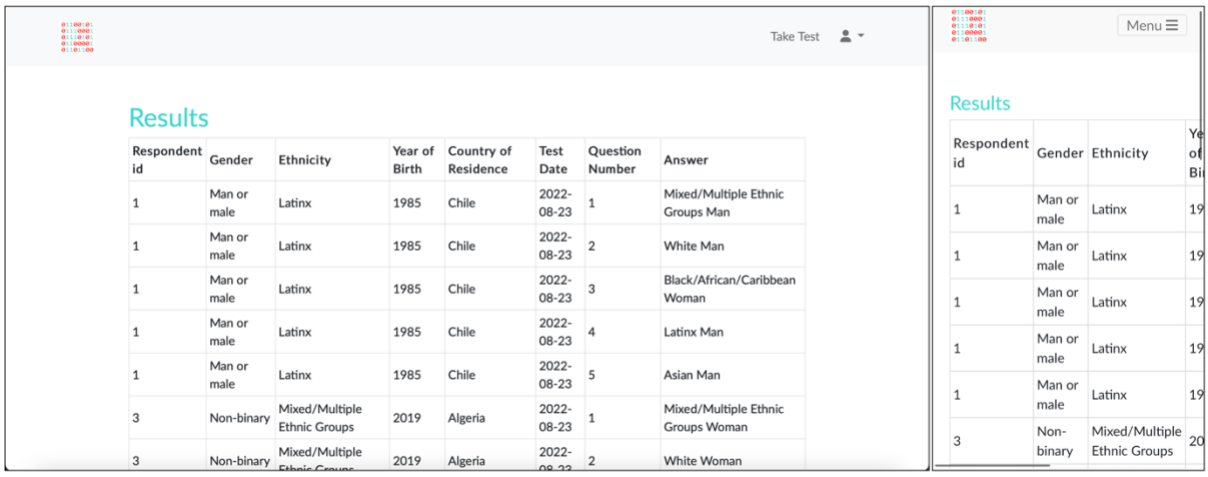

Figure 32: The Binary in the Binary Desktop and Mobile Results Page

The Users view, which is only available to admins, lists all the users and their user group with an Edit button and a Remove button. Figure 33 shows the Users page. The Remove button deletes the user from the database using the removeUser method in the UsersModel. When the admin removes a user (Marion in this example), the alert messages banner displays a success message (see Figure 34). The Edit button redirects the user to the User Editor view (see Figure 35). This view is a simple HTML form that provides the username and a dropdown box to assign a user group to the user. The admin chooses the user group from a dropdown rather than a free-text input field to ensure attackers cannot exploit the web application or database by injecting HTML or JavaScript code. The default user group value is null. Therefore, these users are visitors and only basic privileges are granted. When a user (Emily in this example) gets edited successfully, the admin gets redirected to the Users page, and the alert messages banner displays a success message (see Figure 36). The users view uses the user.css stylesheet. The userseditor view uses the userseditor.css stylesheet.

Figure 33: The Binary in the Binary Desktop and Mobile Users Page

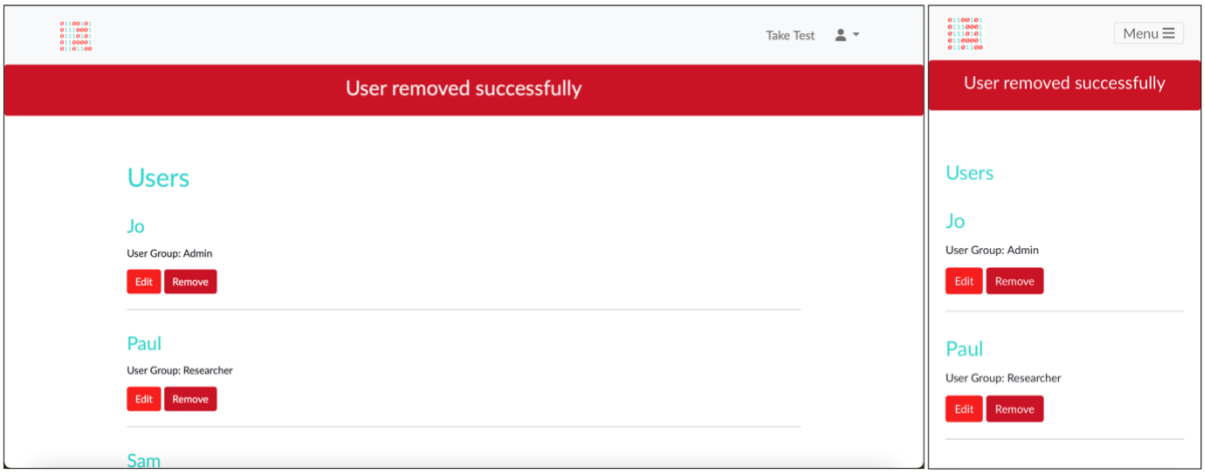

Figure 34: The Binary in the Binary Desktop and Mobile Remove User with Success Message

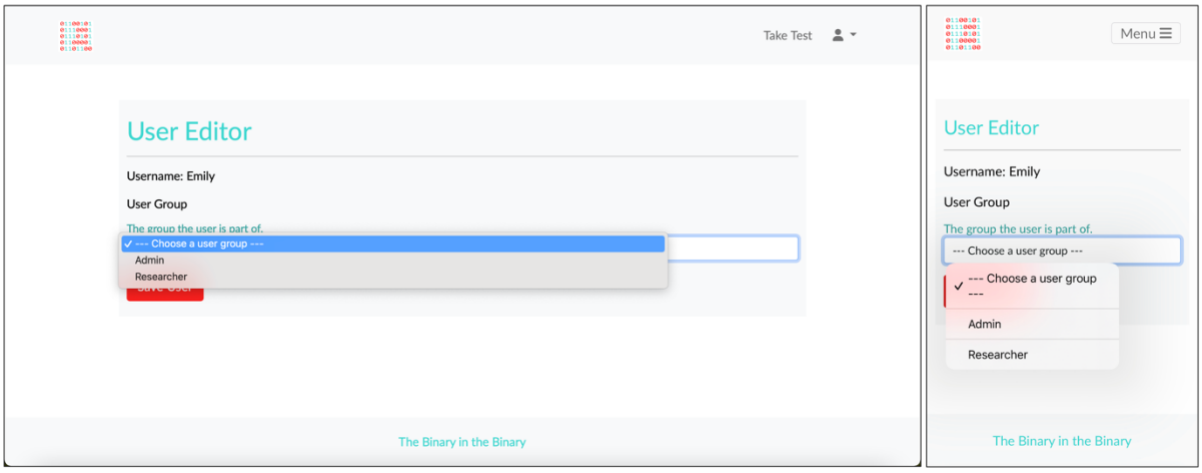

Figure 35: The Binary in the Binary Desktop and Mobile User Editor Page

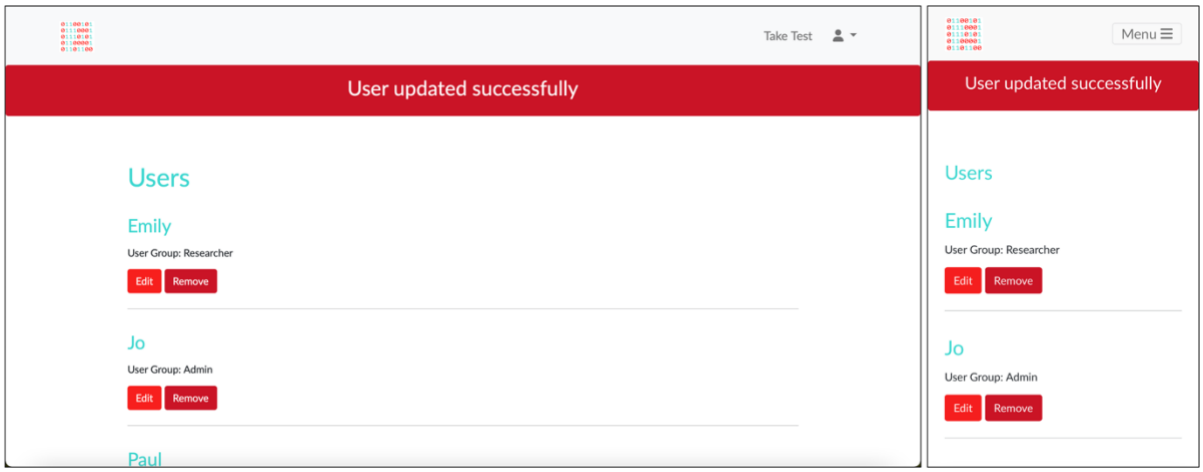

Figure 36: The Binary in the Binary Desktop and Mobile Edit User with Success Message

Obtaining informed consent from research participants is crucial. Therefore, the landing page of the Binary in the Binary web application is the consent view. The Consent page contains the consent details for the Binary in the Binary project and a button for the respondent to click if consent is given. The consent view uses the consent.css stylesheet. Figure 37 shows the Consent page.

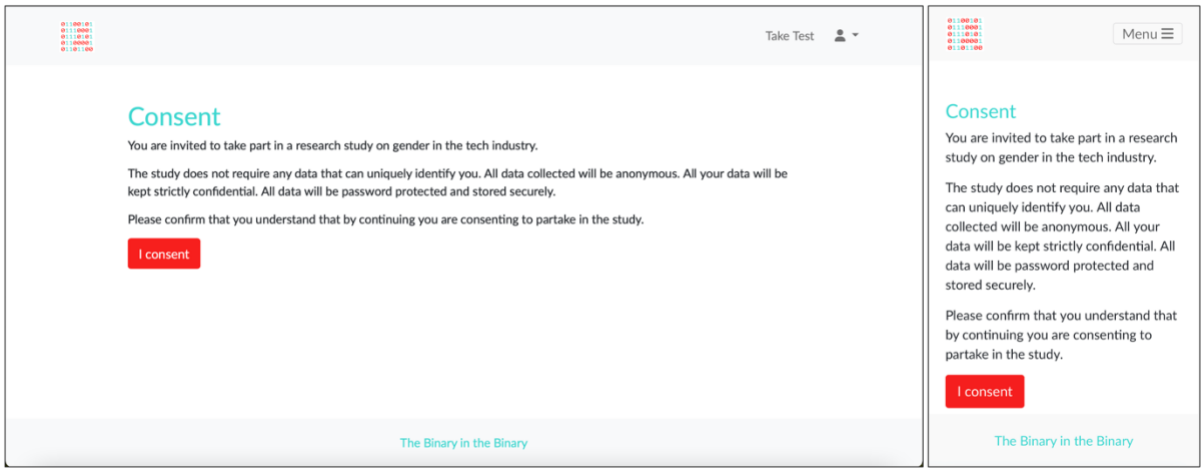

Figure 37: The Binary in the Binary Desktop and Mobile Consent Page

The respondent view is an HTML form that accepts the respondent's demographics, including gender, ethnicity, year of birth, and country of residence (see Figure 38). It is important to note that all the respondent demographic data is collected anonymously, and the database contains no identifiable data. The respondent cannot continue and proceed to the survey until all the demographic questions have been answered. Again, the respondent selects the answers from dropdowns to ensure protection against attackers. The respondent view uses the respondent.css stylesheet.

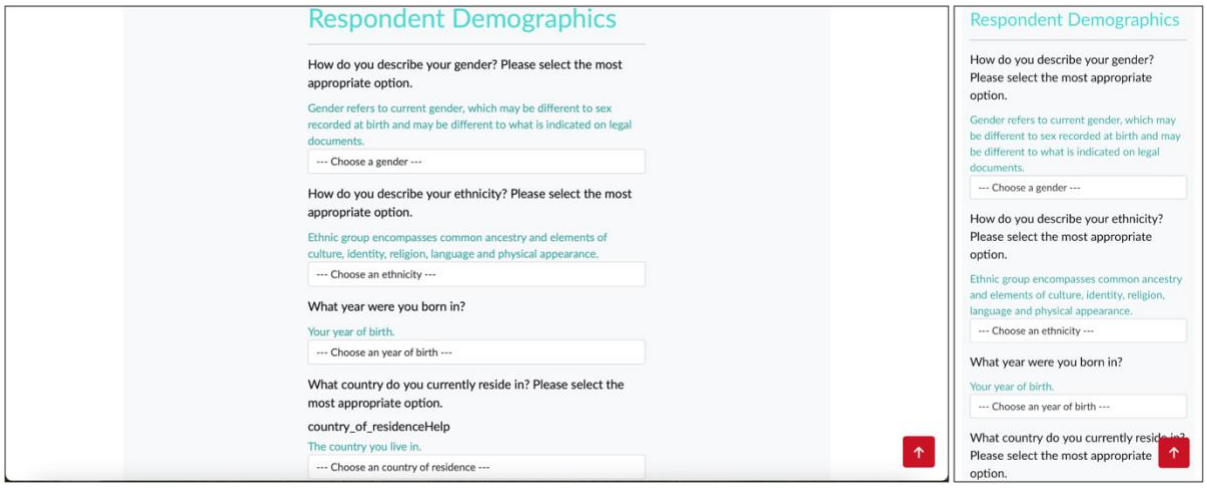

Figure 38: The Binary in the Binary Desktop and Mobile Respondent Demographics Page

Given gender is a crucial aspect of this study, I was determined to ensure that the Binary in the Binary web application asks about gender in a sensitive and inclusive manner (Vanderbilt University, 2022). Thus, I used the 2020 Standard for Sex, Gender, Variations of Sex Characteristics and Sexual Orientation Variables developed by the Australian Bureau of Statistics (2021) as a guide on how to ask for survey respondents' gender. Figure 39 shows the gender question, help, and dropdown options. Similarly, asking about ethnicity is complex. With this in mind, I used the recommended ethnicities provided by the UK Office for National Statistics (2021). Figure 40 shows the ethnicity question, help, and dropdown options. The alert messages banner displays an error message informing the user if they have not answered all the demographics questions (see Figure 41).

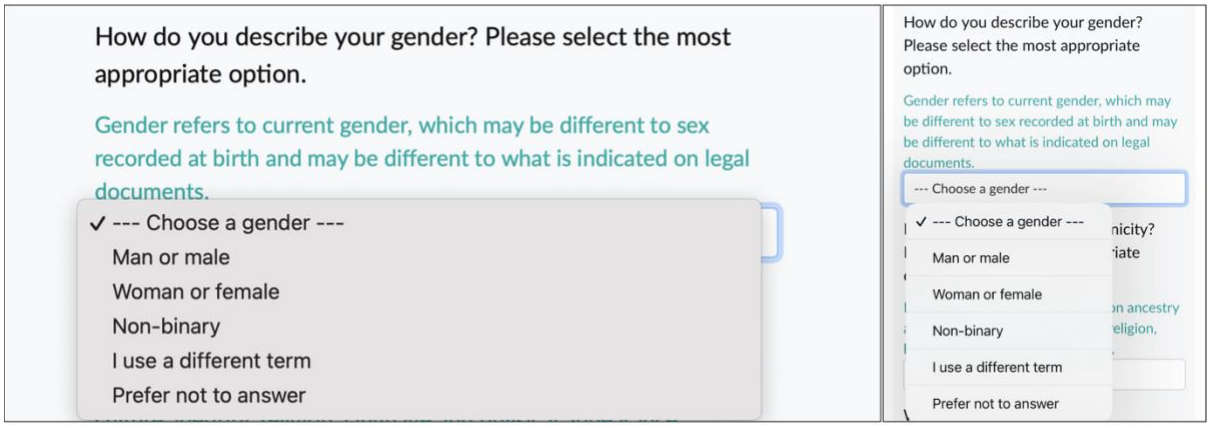

Figure 39: The Binary in the Binary Desktop and Mobile Respondent Demographics Gender Question

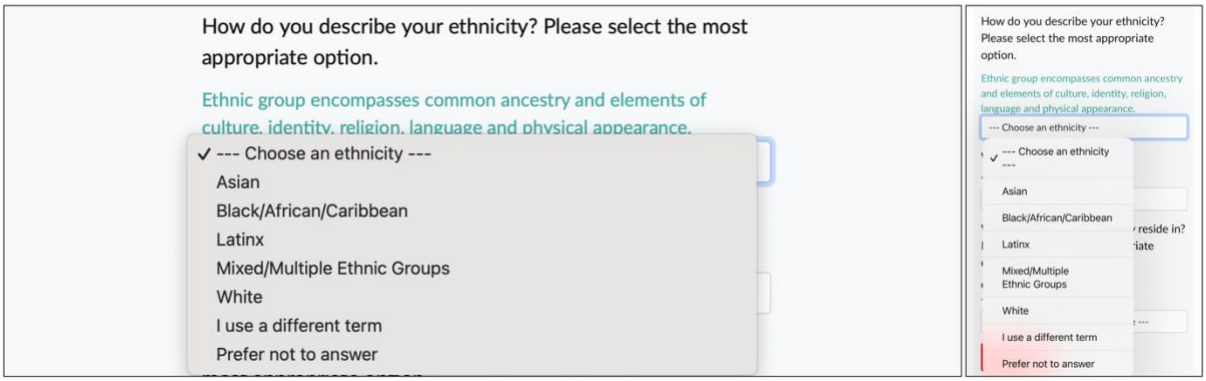

Figure 40: The Binary in the Binary Desktop and Mobile Respondent Demographics Ethnicity Question

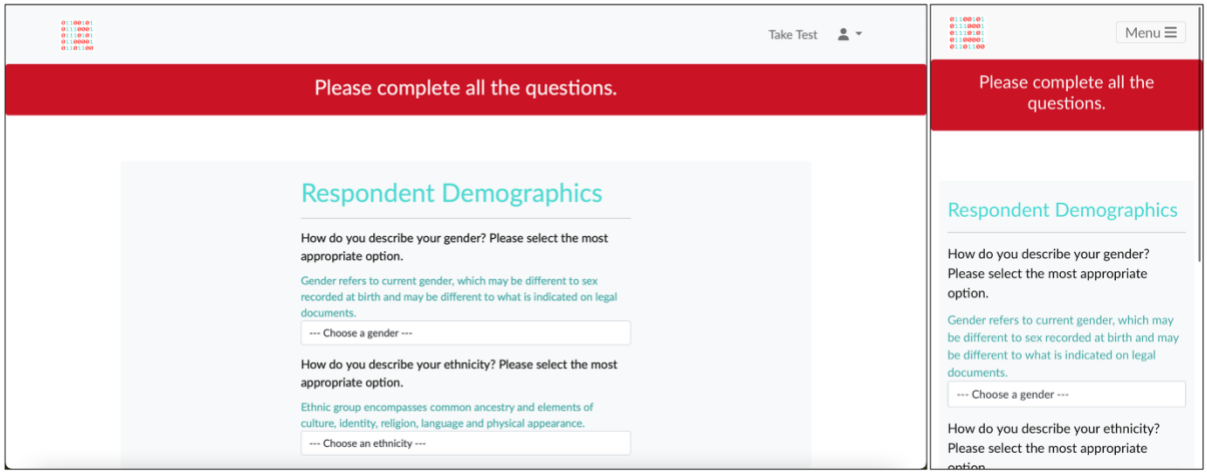

Figure 41: The Binary in the Binary Desktop and Mobile Respondent Demographics Page with Error Message

The responseone (see Figure 42), responsetwo (see Figure 43), responsethree (see Figure 44), responsefour (see Figure 45), and responsefive (see Figure 46) views are all very similar. All these pages use the response.css stylesheet. Each response page has three hidden fields: question_number, respondent_id, and test_date. The question_number changes according to the response number. The respondent_id is retrieved from the session array. The test_date field value is NOW(), which returns the current date when inserted into the SQL statement. The respondent answers the question, “Who will be in a more senior position in the tech industry

in 5 years?" by clicking on one of two buttons, each with an image of a person. To test perceptions about how gender affects career progression in the tech industry, I held ethnicity constant, but the gender of the persons displayed on each button was variable. Table 1 shows the response button variables for the Binary in the Binary proof-of-concept web application.

Response Number	Button Contents		Button Contents	
	Gender	Ethnicity	Gender	Ethnicity
1	Man or male	Mixed/Multiple Ethnic Groups	Woman or female	Mixed/Multiple Ethnic Groups
2	Man or male	White	Woman or female	White
3	Man or male	Black/African/Caribbean	Woman or female	Black/African/Caribbean
4	Man or male	Latinx	Woman or female	Latinx
5	Man or male	Asian	Woman or female	Asian

Table 1: The Variables for the Binary in the Binary Web Application Response Buttons to Test Gender

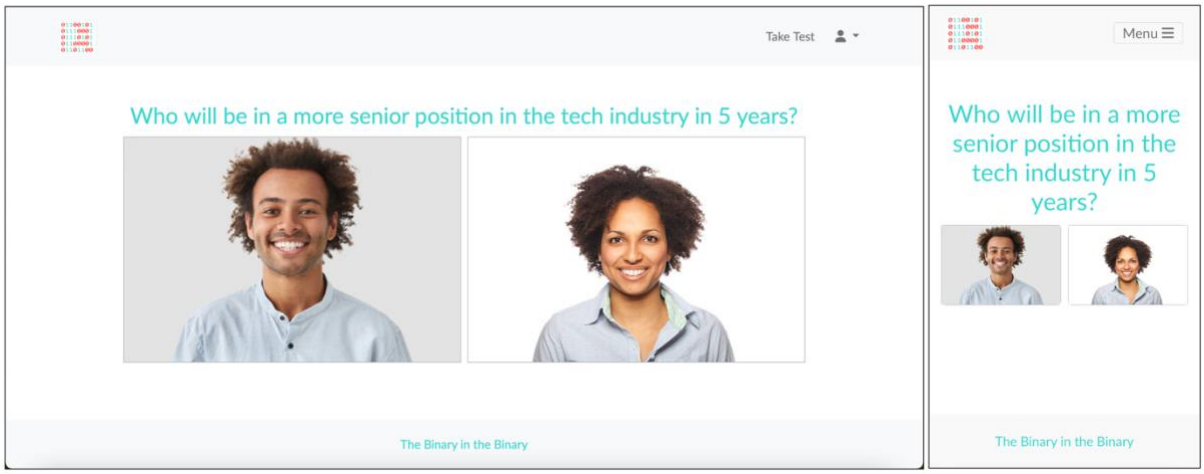

Figure 42: The Binary in the Binary Desktop and Mobile Response One Page

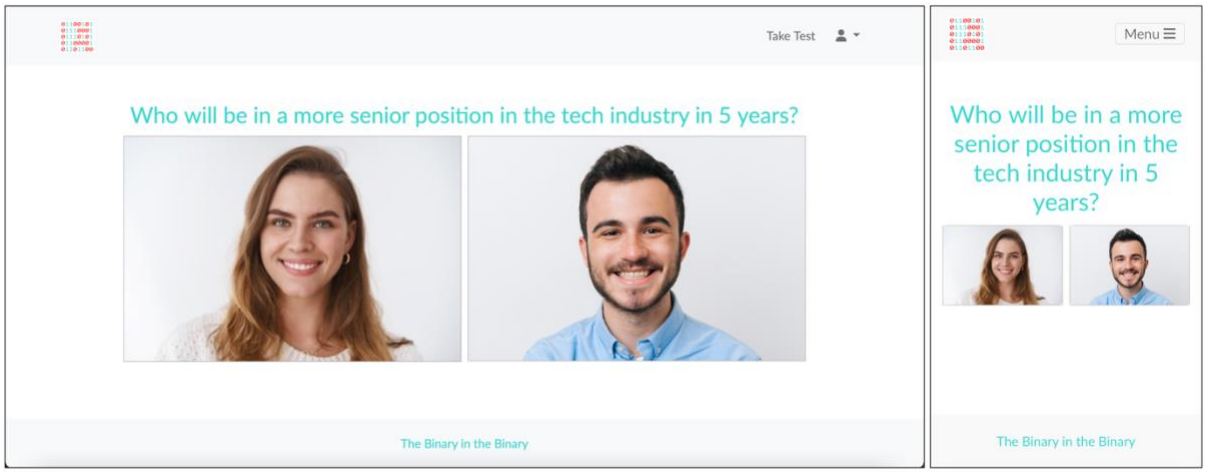

Figure 43: The Binary in the Binary Desktop and Mobile Response Two Page

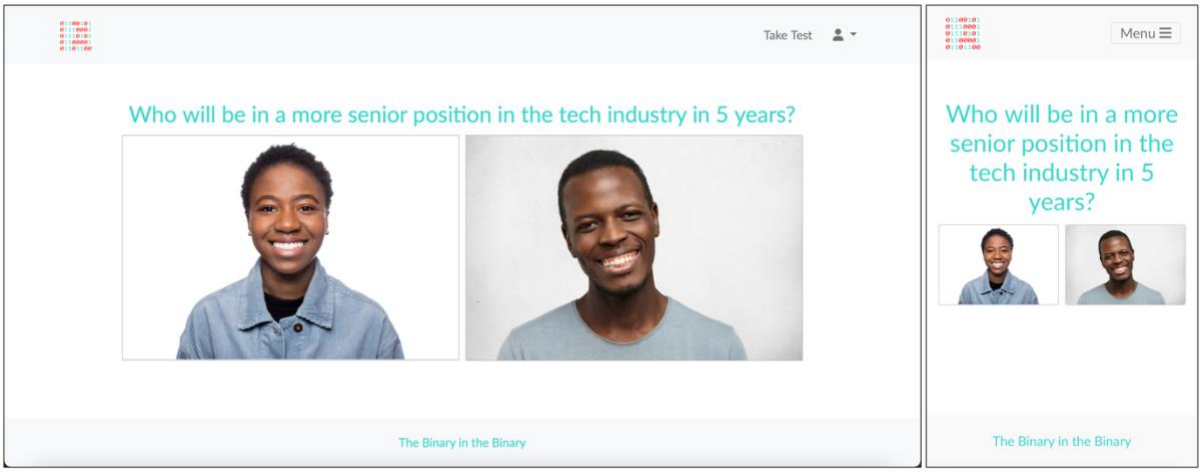

Figure 44: The Binary in the Binary Desktop and Mobile Response Three Page

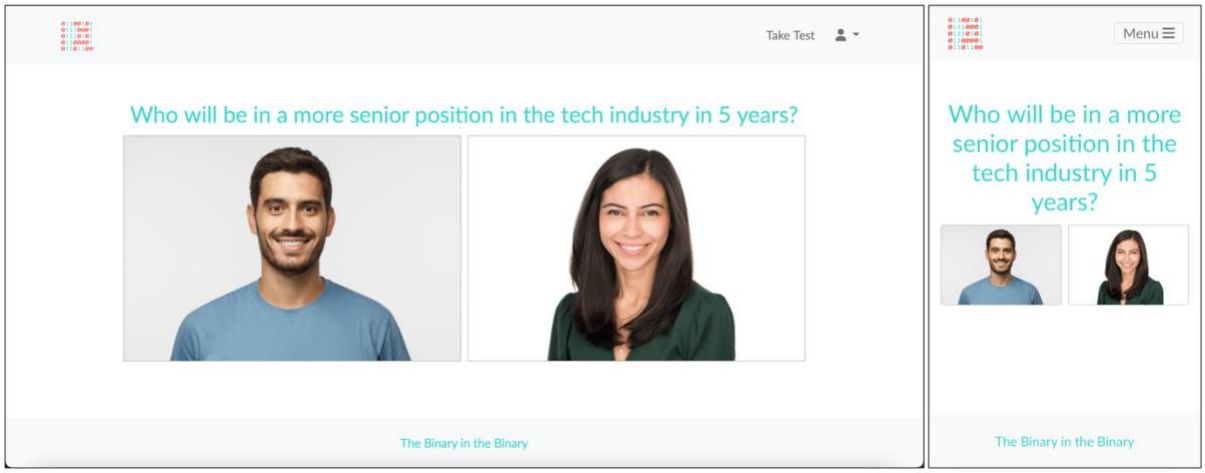

Figure 45: The Binary in the Binary Desktop and Mobile Response Four Page

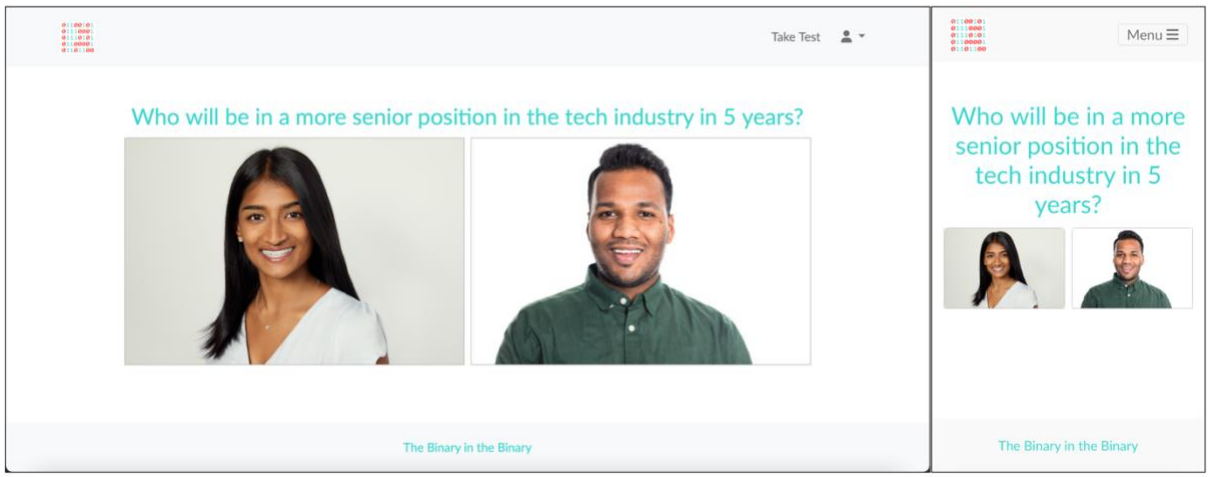

Figure 46: The Binary in the Binary Desktop and Mobile Response Five Page

Once the respondent has answered all the survey questions, they are directed to the thanks view. The Thanks page displays the primary logo (see Figure 3) and thanks the respondent for participating in the study (see Figure 47). This view implements the thanks.css stylesheet.

Figure 47: The Binary in the Binary Desktop and Mobile "Thanks" Page

It is important to note that the Binary in the Binary web application secondary logo (see Figure 3) is displayed on the tab of the website (see Figure 48) as well as in the user's bookmark or favourites lists (see Figure 49).

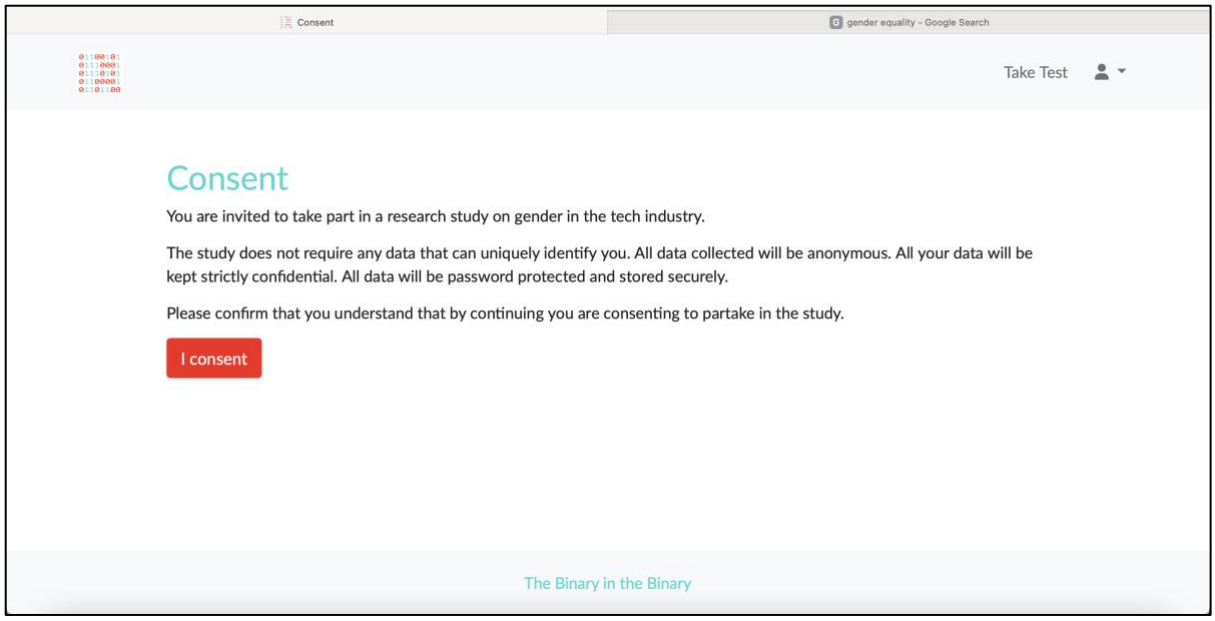

Figure 48: The Binary in the Binary Logo in Tab

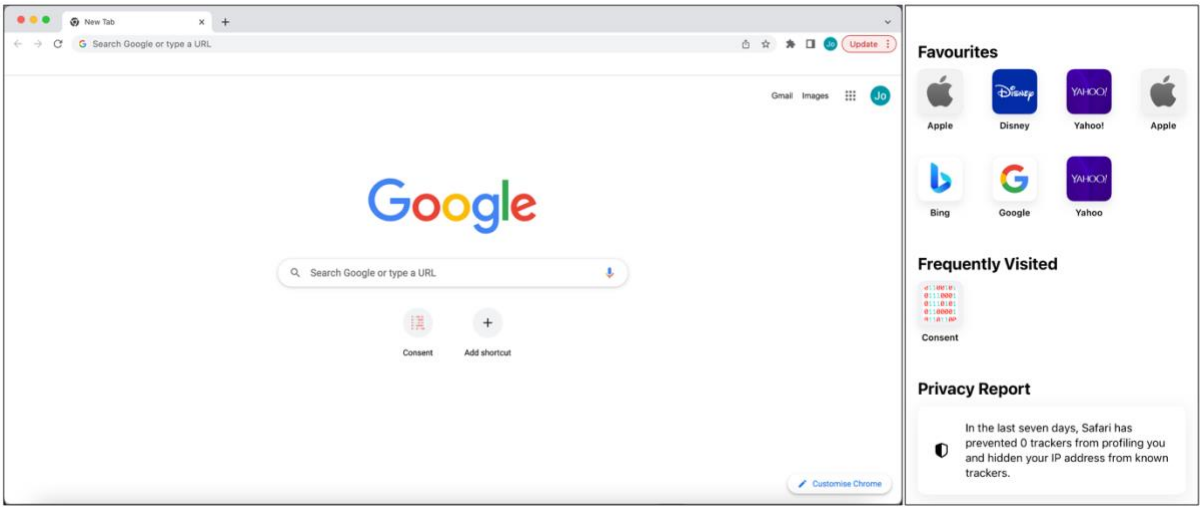

Figure 49: The Binary in the Binary Logo in Bookmark or Favourites List for Desktop and Mobile

4.3.3. The Controller Layer

The controller layer processes the user's interactions (Leff and Rayfield, 2001). The Binary in the Binary web application has sixteen controller classes.

The Controller class is the super controller class that contains the common properties and methods used by the sub-controllers. This class has three protected properties, $data, $view, and $head, that store the data injected into the view layer after the controller processes a request and retrieves the associated data from the model. The renderView method displays the view. The redirect method redirects to the page passed into the method. The addMessage method adds a flash message to the session array. The getMessages method gets the messages from the session array. The authUser method confirms if a user has access to a page and, if not, redirects the user to the failure view. The remaining fifteen controller classes are sub-classes of the Controller class.

The RouterController class processes requested URLs and renders the appropriate view into the layout template using the process method. The process method makes necessary transformations using the dashesToCamel and parseUrl methods. The parseUrl method parses the URL address using slashes and returns the URL parameters as an array. The dashesToCamel method converts the controller's name from the URL into a CamelCase class name.

The ConsentController and ThanksController classes are simple classes that contain a process method. Each method stores the HTML $head data and sets the associated view.

The FailureController class contains a process method that instantiates a UserModel object that retrieves the data of the user currently logged in. If the URL passed into the method contains “logoff” in the array, the logged-in user is logged off using the logoff method in the UsersModel class and redirected to the Login page. The method also stores the HTML $head data and sets the view to failure.

The LoginController class contains the process method, which instantiates a UserModel object. If a user has logged in already, then the user is redirected to the results page. Alternatively, it attempts to log a user in using the login method from UserModel. Additionally, the method stores the HTML $head data and sets the view to login.

Similarly, the RegisterController class process method instantiates a UserModel object. If the user requests the register page but has logged in already, they get redirected to the results page. Otherwise, a new user is registered using the UserModel register method. The method stores the HTML $head data and sets the register view.

The RespondentController class process method instantiates a RespondentModel object. When the respondent form is submitted, the method first checks if the respondent answered all the demographics questions, then attempts to save the respondent demographics using the registerRespondent method in the RespondentModel and re-directs to the responseone view. The process method stores the HTML $head data and sets the view to respondent.

The ResponseoneController, the ResponsetwoController, the ResponsethreeController, the ResponsefourController, and the ResponsefiveController are all very similar. Each process method instantiates a ResponseModel object to save the respondent's answer using the

saveResponse method. The method redirects the to the next response (for example, if on responseone to responsetwo). Once the user answers the last question (responsefive), they get redirected to the thanks view. The process method stores the HTML $head data and sets the view to the respective respondent view.

The ResultsController class process method uses the authUser method to allow researchers access to view the Results page. The method instantiates a ResultsModel object and a UsersModel object. If the URL passed into the method contains “logoff” in the array, the logged-in user is logged off using the logoff method in the UsersModel class and redirected to the login page. Alternatively, the ResultsModel object retrieves the results using the getResults method. The process method stores the HTML $head data and sets the view to results.

The UsersController class process method instantiates a UserModel object and a UsersModel object. The UserModel retrieves information about the current user. If a remove action is in the URL and the current user is an admin, they can delete users using the removeUser method in the UsersModel class. Alternatively, all the users are listed using the getUsers method in the UsersModel. The process method also stores the HTML $head data and sets the users view.

The UserseditorController class process method instantiates a UsersModel object. When a form is submitted, the method retrieves the keys from $_POST and attempts to update the user details using the updateUser method in the UsersModel class. The user is always redirected to the Users page regardless of whether the update was successful or not. The process method stores the HTML $head data and sets the view to userseditor.

4.4. Testing

A vital objective of an agile development approach is to "continuously turn out tested working software (Abrahamsson et al., 2017, p. 13)." Therefore, while developing the Binary in the Binary web application, I tested perpetually.

I used HTML Validator to ensure that the web application did not include any HTML errors. Additionally, I used the WAVE web accessibility evaluation tool to identify and amend accessibility errors. This is important to ensure that the Binary in the Binary web application is usable to people with disabilities.

To test the responsiveness of the web application, I ran the web application on both desktop and mobile devices. In addition, I tested the Binary in the Binary web application on multiple browsers, namely: Safari and Google Chrome.

When the Binary in the Binary web application was complete, I executed unmoderated remote usability testing. This testing involves participants completing tasks "in their own environment using their own devices and without a moderator present, which leads to the product being used naturally (Babich, 2019)." I asked my peers to complete the survey and provide feedback about the web application navigation, UI, and UX, which also tested the web application authentication and authorisation mechanisms.

5. From Proposal to Implementation

I developed the Binary in the Binary web application as a proof of concept for a major study on how gender affects people's perceptions about career progression in the tech industry. The Binary in the Binary project is a fully functioning, responsive, PostgreSQL database-driven web application and is evidence that the project proposal is indeed feasible. However, if implemented, there are additional processes and features I would improve upon or incorporate. Given that I adopted an agile methodology while developing the Binary in the Binary project, these late changes in specification are not problematic (Abrahamsson et al., 2017). Additionally, I kept the code as straightforward and technically advanced as possible by implementing an MVC design pattern, using OOP, and making thorough comments on the code. This is important to ensure that the code is easy to change and/or improve.

The first feature I would improve for the project implementation is the consent form details. As previously discussed, acquiring consent from respondents is crucial. Although the consent form (see Figure 37) is sufficient for the proof-of-concept web application, if implemented, the Binary in the Binary project would require a more detailed and comprehensive consent form. Users must be made aware of what data is collected and how this data is stored.

Another feature I would improve prior to project implementation is the results page (see Figure 32). Again, although the current view is sufficient for the proof-of-concept web application, I would improve the UI by making the results table sortable. I would also include search functionality. In addition, I would add functionality to enable the researchers to download the results as a CSV file. This would make working with and analysing the results much simpler for the researchers.

I have put considerable effort into ensuring that the Binary in the Binary project is as inclusive as possible. However, if implemented, I would incorporate functionality to ensure the web application is multilingual. Removing language barriers is crucial because it enables more people to participate in the study, thereby improving the results and ultimately the usefulness of the project.

For the Binary in the Binary proof of concept web application, I attempted to select the images of people (see Figure 42 to Figure 46) ethically. However, if the project went further, this process would need more consideration and additional research into the scientific methods of choosing appropriate survey images. Furthermore, I downloaded the images from the internet for the proof-of-concept web application. However, in its more advanced form, the project should either have images that are available under open licences or should purchase a licence that provides the rights to use images. One can acquire these licences from a stock photo provider such as Shutterstock. In addition, I would ensure that the images used are web friendly. I would use GIMP to edit, optimise, and reduce the size of the images.

The Binary in the Binary proof-of-concept web application only tests how gender affects career progression in the tech industry. As discussed in Section 4.3.2., this is done by holding ethnicity constant, but changing the gender of the two people shown on each response page. Table 1 shows the combinations of gender and ethnicity of the people on the buttons on the response pages. These questions are adequate for the proof-of-concept because they provide sufficient evidence that the web application functionality is successful.

However, as discussed in Section 3.2, this research is informed by intersectional liberal feminism. Therefore, it is important to acknowledge, address, and collect data about the

compounded experiences of discrimination faced by people who have multiple social identities. If implemented, I would extend the functionality of the Binary in the Binary proof of concept web application in order to track how ethnicity and the intersection of gender and ethnicity influences people's perceptions about career progression in the tech industry.

To do this, the survey would ask the respondent an additional 40 questions using the same method and images as the proof-of-concept web application (see Figure 42 to Figure 46). To test how ethnicity affects perceptions on career progression in the tech industry, the gender of the two people shown on each response page is held constant, while ethnicity changes. Table 2 details variations/combinations of gender and ethnicity used to test the effect of ethnicity. Furthermore, to test how the intersection of gender and ethnicity influences perceptions on career progression in the tech industry, both the gender and the ethnicity of the two people shown are different. Table 3 details the combination of gender and ethnicity of the people on the response pages to test the effect of the intersection of gender and ethnicity on participants' perceptions. By adding these questions, the Binary in the Binary project takes on a more intersectional approach. One could develop the Binary in the Binary project even further to include other identity categories, such as age, sexuality, and social class.

Response Number	Button Contents		Button Contents	
	Gender	Ethnicity	Gender	Ethnicity
6	Woman or female	Mixed/Multiple Ethnic Groups	Woman or female	White
7	Woman or female	Mixed/Multiple Ethnic Groups	Woman or female	Asian
8	Woman or female	Mixed/Multiple Ethnic Groups	Woman or female	Black/African/Caribbean
9	Woman or female	Mixed/Multiple Ethnic Groups	Woman or female	Latinx
10	Woman or female	Asian	Woman or female	White
11	Woman or female	Asian	Woman or female	Black/African/Caribbean
12	Woman or female	Asian	Woman or female	Latinx
13	Woman or female	Black/African/Caribbean	Woman or female	White
14	Woman or female	Black/African/Caribbean	Woman or female	Latinx
15	Woman or female	Latinx	Woman or female	White
16	Man or male	Mixed/Multiple Ethnic Groups	Man or male	White
17	Man or male	Mixed/Multiple Ethnic Groups	Man or male	Asian
18	Man or male	Mixed/Multiple Ethnic Groups	Man or male	Black/African/Caribbean
19	Man or male	Mixed/Multiple Ethnic Groups	Man or male	Latinx
20	Man or male	Asian	Man or male	White
21	Man or male	Asian	Man or male	Black/African/Caribbean
22	Man or male	Asian	Man or male	Latinx
23	Man or male	Black/African/Caribbean	Man or male	White
24	Man or male	Black/African/Caribbean	Man or male	Latinx
25	Man or male	Latinx	Man or male	White

Table 2: The Variables for the Binary in the Binary Web Application Response Buttons to Test Ethnicity

Response Number	Button Contents		Button Contents	
	Gender	Ethnicity	Gender	Ethnicity
26	Woman or female	Mixed/Multiple Ethnic Groups	Man or male	White
27	Woman or female	Mixed/Multiple Ethnic Groups	Man or male	Asian
28	Woman or female	Mixed/Multiple Ethnic Groups	Man or male	Black/African/Caribbean
29	Woman or female	Mixed/Multiple Ethnic Groups	Man or male	Latinx
30	Woman or female	Asian	Man or male	White
31	Woman or female	Asian	Man or male	Mixed/Multiple Ethnic Groups
32	Woman or female	Asian	Man or male	Black/African/Caribbean
33	Woman or female	Asian	Man or male	Latin
34	Woman or female	Black/African/Caribbean	Man or male	White
35	Woman or female	Black/African/Caribbean	Man or male	Mixed/Multiple Ethnic Groups
36	Woman or female	Black/African/Caribbean	Man or male	Asian
37	Woman or female	Black/African/Caribbean	Man or male	Latinx
38	Woman or female	Latinx	Man or male	White
39	Woman or female	Latinx	Man or male	Mixed/Multiple Ethnic Groups
40	Woman or female	Latinx	Man or male	Asian
41	Woman or female	Latinx	Man or male	Black/African/Caribbean
42	Woman or female	White	Man or male	Mixed/Multiple Ethnic Groups
43	Woman or female	White	Man or male	Asian
44	Woman or female	White	Man or male	Black/African/Caribbean
45	Woman or female	White	Man or male	Latinx

Table 3: The Variables for the Binary in the Binary Web Application Response Buttons to Test the Intersection of Gender and Ethnicity

Finally, despite the testing already performed on the proof-of-concept web application (discussed in Section 4.4), the Binary in the Binary project would need to be tested thoroughly before implementation. This is crucial because the respondents and users should not face any hindrances when using the web application. Session recording would be an ideal method to identify any interaction issues faced by the Binary in the Binary web application users (Babich, 2019).

6. Conclusion

The purpose of this study was to identify the factors that influence women's persistence and advancement in the tech industry. I performed an extensive literature review using an intersectional liberal feminist lens, in which I identified three major themes, namely: individual experience, culture, and career progression.

This research informed the design and agile development of the Binary in the Binary project, a proposal for a research tool used to test people's perceptions about how gender affects career progression in the tech industry. To achieve this objective, I designed and coded the proof-of-concept web application because I wanted the project on women in tech to be developed by a woman involved closely, yet objectively, in tech. The Binary in the Binary is a PostgreSQL database-driven responsive web application coded in PHP and JavaScript following the MVC design pattern and run on the open-source Apache HTTP Server. The dissertation detailed the design process and provided the style guide, desktop and mobile wireframes used in the development process. It then proceeded to explain the development of the Binary in the Binary web application, which was separated into three layers: the model, the view, and the controller.

This dissertation provided evidence that the Binary in the Binary project proposal is feasible. I suggest that the study is repeated annually to identify recent trends and to track whether respondents' opinions have shifted. Additionally, the dissertation detailed the suggested improvements and the features to incorporate if implemented. This includes enhancing the consent form, results page, and image selection process as well as introducing multilingual functionality and further testing. The most significant improvement is that the web application should be developed further to take on a more intersectional approach by including the

functionality of testing how ethnicity and the intersection of gender and ethnicity influences people's perceptions on career progression in the tech industry.

With the ultimate goal of feminist research in mind, identifying, documenting, and collecting data on the factors that influence women's persistence and advancement in the tech industry is crucial to bring about social change and achieve equality. Organizations in the tech industry can use the research provided in this dissertation and the data from the Binary in the Binary project to identify areas that need attention and make improvements to ensure an inclusive and diverse workforce. The research and project results are useful to enlighten men on women's experience of the tech industry. Finally, this dissertation is crucial because it warns and prepares women about the "bugs" they may face in their careers, thereby, enabling more women to persist and advance in the tech industry.

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