Liberatory Computing Framework: Empowering High School Students to Mitigate Systemic Oppression through Data Activism

by

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Submitted to the Program in Media Arts and Sciences
School of Architecture and Planning
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Abstract

One reason for the underrepresentation of African Americans in the field of computing is the lack of opportunities to engage with data science, particularly in ways that empower their communities. Current computing curricula do not teach students how to leverage technical skills in service of projects that are more authentic and relevant to the African Americans they are claiming to assist. While computing has the potential to change the world and has become increasingly integrated into our daily lives, the longstanding reality remains that minoritized groups, including African Americans, are underrepresented in computing fields. Moreover, computing classes often present computing as abstract, neutral, and utopian, disregarding its potential for causing harm.

While it is important for everyone to participate in the process of dismantling a complex system of barriers, I focus specifically on why this goal is of particular relevance to African American students. I highlight Dr. El-Amin's "liberation tools," which state how a sound racial identity, critical consciousness, liberation centered achievement identity, collective obligation, along with activism skills are essential to preparing African Americans to "fight for" racial liberation. Given that computing classes teach students critical thinking skills to solve complex problems, I argue that computing is well-positioned to incorporate "liberation tools". Liberation tools teach students how to think in terms of systems, which is essential for racial liberation. By expanding the liberation tools, I coin the term, "liberatory computing," to reveal how computing curricula can motivate and provide African American students with practical skills to address the racism embedded in society.

I propose two innovative high school curricula that focus on data activism, integrating lessons on racism with the practical application of robust data science skills to support community organizers in their efforts. In the first data activism program, students utilize their data science and social justice skills to address systemic racism

through an independent capstone project. They actively engage in conducting background research on specific instances of systemic racism, identifying relevant data sets, and implementing intersectional data analysis techniques. In the second data activism program, students collaborate with community partners to work on a data activism project aimed at supporting minoritized groups in the Greater Boston area. This comprehensive research project encompasses various essential components, such as analyzing student projects, conducting surveys and interviews, and seeking insights from community organizers.

Notably, all community organizers expressed their intention to utilize the students' data activism projects as a valuable resource to enhance their advocacy efforts. For example, one community organization plans to leverage the student's intersectional data visualizations to advocate for policies and laws that address the issue of inland flooding in predominantly African American and low-income communities in Boston. In the second program, surveys indicated a significant increase in the number of students who now acknowledge the impact of data science in combating racism, along with an increased ability to employ their academic achievements to mitigate racial injustices. Furthermore, interviews conducted with students who participated in the second program revealed a unanimous desire to incorporate data activism into their future endeavors. Impressively, twelve out of seventeen students discussed specific ideas on how they plan to utilize data science and social justice principles in their forthcoming pursuits.

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Introduction

1.1 Motivation

The persistent underrepresentation of African American students in computing is a complex issue rooted in historical factors, such as systemic racism and negative societal messages that explicitly or implicitly suggest African Americans are not suited for computing. Even today, we continue to witness the lasting effects of this underrepresentation in computing. Without a sense of belonging, it's unrealistic to expect a more diverse computing workforce [40]. Despite efforts, the percentage of computer science Bachelor's degrees awarded to Black or African American students has not exceeded 4% over the past few years [51, 16, 11, 45]. Additionally, there has been limited research conducted on each subgroup [44, 27, 21, 20, 14]. Therefore, it is of utmost importance to prioritize investments in mitigating the factors that contribute

to the underrepresentation of African Americans in computing. By doing so, we can pave the way for a future that is more diverse, inclusive, and equitable for African Americans in the field of computing.

Quincy (2021) and Wang (2017) discuss the numerous social and systemic barriers that hinder African American students' exposure to computing, such as underfunded schools, stereotypes, stereotype threat, and racism [11, 49]. Moreover, a vast amount of curricula do not incorporate the community knowledge and social experiences of African American students [27, 36]. In order to empower African American students to utilize computing as a tool to dismantle the systemic racism they encounter, it is essential that curricula actively facilitate these discussions and provide a platform for exploring these issues. However, computing courses often present computing as a neutral field without a connection to social justice [38, 41, 19], while disregarding how technology is utilized to surveil, police, and incarcerate African American communities [13, 10, 39].

Furthermore, to the best of my knowledge, there is currently a lack of data science curricula specifically designed for African American high school students to address the unique and detrimental manifestations of racism and oppression they confront. To empower African American students to bring about transformative change, it is imperative to develop computing curricula that not only equip them with the skills to navigate society, but also enable them to utilize computing as a means of societal transformation. The aforementioned challenges emphasize the critical importance of developing a comprehensive framework that incorporates liberation tools specifically tailored to address the needs and experiences of African Americans in the field of computing.

Liberatory computing is a solution to teach students how to use computing to support minoritized groups [48]. Liberatory computing is a framework that ensures African American students acquire five pillars of the liberation framework developed by El-Amin: (1) a sound racial identity, (2) critical consciousness, (3) collective obligation, (4) a liberation centered academic identity, and (5) the activism skills to use computing to transform a multi-layered system of barriers in which racism persists.

The liberation framework is defined as "an alternative contemporary emancipatory school model for African Americans that is attentive and responsive to the powerful role of racism in African Americans lives, and is intended to prepare African Americans not just to thrive in this society but also – as racial liberation truly requires – to re-envision society and create a fully humanizing alternative" [15].

I present two data activism curricula that incorporate liberatory computing, specifically designed for African American high school students, with the goal of empowering them to utilize computing to address systemic racism. Data activism involves using data science to challenge power inequalities, including racism [23]. It is important to note that data activism does not require collaboration with a community organization. In addition, a key objective of the data activism curricula are to empower students with the necessary skills to integrate data activism into their everyday lives. This thesis investigates the impactful contributions of this work to African American students in the context of liberatory computing. It includes a comprehensive evaluation of the data activism curricula that was taught to students from the Cambridge Mayor's Summer Youth Employment Program (MSYEP) and African American students from the Greater Boston area. My thesis delves into the methodology employed to address the research questions, followed by a comprehensive analysis of the results utilizing both quantitative and qualitative approaches. Furthermore, this thesis offers insights into potential directions for future research and exploration in the field of liberatory computing.

1.2 Contributions

My thesis advances the field of computing education by introducing an innovative framework for curriculum development that integrates liberation tools, known as liberatory computing. The incorporation of data activism curricula plays a vital role in empowering African American students with essential skills to confront power inequalities and drive social change through data science. The effectiveness of these curricula were evaluated through meticulous analysis of data activism projects,

interviews, and surveys. The ultimate objective of liberatory computing is to encourage greater utilization of computing among African Americans, equipping them to confront systemic racism and advocate for social justice. This thesis offers several noteworthy contributions to the field of computing education:

1. A novel framework for creating computing curricula that incorporates liberation tools, called liberatory computing
2. Over 150 hours of data activism curricula has been developed to teach African American high school students how to use data science to dismantle power inequalities, such as racism
3. Evaluation studies and insights into the efficacy of two data activism curricula with the participation of students from the Cambridge Mayor's Summer Youth Employment Program (MSYEP) and African American students from the Greater Boston area
4. During the second data activism program, students actively engaged with community organizers from the Greater Boston area, employing the Critical Participatory Action Research (CPAR) framework. All community organizers involved have expressed their intent to leverage the students' research to strengthen and amplify their advocacy efforts in vital areas such as inaccessible housing, food insecurity, and environmental injustice.
5. The surveys conducted after the second program revealed a significant surge in the percentage of students who acknowledged the transformative power of data science in combating racism and using their academic achievements to address these systemic injustices.
6. Interviews with students revealed a unanimous desire to incorporate data activism into their future endeavors. Twelve out seventeen students presented specific ideas on how to apply data science and integrate social justice principles in their future pursuits.

To assess the impact of both data activism programs, I have identified several key metrics to target. These metrics encompass the students' increased utilization and

proficiency with each liberatory computing tool, as well as their ability to contribute intersectional data analyses to their respective community organizations. These measures serve as critical indicators for evaluating the programs' effectiveness in empowering students to become confident data activists within their communities. Ideally, students will gain the confidence to independently discover relevant data sets online or collect their own data that aligns with the systemic issues they are passionate about. This newfound confidence will empower them to provide valuable support to their communities through data-driven insights and analysis. At the very least, it would be highly beneficial if students feel more self-assured in employing data to inform their decision-making and raise awareness about the issues close to their hearts after the data activism program concludes.

This thesis focuses on the following main research question:

> How do the data activism curricula prepare students to engage in data activism? Additionally, what is the impact of implementing different data activism curricula on students' proficiency in each liberatory computing pillar?

For the first data activism program conducted with the Cambridge Mayor's Summer Youth Employment Program, the specific research question is:

> How does equipping students with skills to conduct intersectional data analysis on a systemic issue of their choice enable students' proficiency in each liberatory computing pillar?

The research question for the second data activism program with African American students from the Greater Boston area is:

> How does equipping students with intersectional data analysis skills and integrating CPAR (Critical Participatory Action Research) skills enable students' proficiency in each liberatory computing pillar?

2

Background and Relevant Work

2.1 Liberatory Computing

In 1619, African American slaves were prohibited by law from learning how to read and write, and anyone caught doing so faced the penalty of death [24]. Even after slavery was abolished, the implementation of "separate but equal," or Jim Crow laws, resulted in an inequitable educational system where African American students were forced to attend underfunded schools that were far from equal [4]. They were also more likely to receive harsher punishments and be expelled compared to their Caucasian peers [22]. However, the principles of this curriculum can be applied to other races as well since examining the success of students who have been historically minoritized can reveal important pedagogical principles for achieving success for all students [30, 15]. El-Amin states, "Mind-bogglingly, we do almost nothing

to intentionally help African Americans counter or resist the pervasive messages of society in schools" [3, 15]. As a result, we propose a curriculum that addresses the racist and violent history against African Americans by incorporating discussions on how liberatory computing can assist African Americans in deconstructing racism. It is impossible to use computing to transform society without addressing these five pillars.

El-Amin created the liberation framework for African Americans because "the situation of African Americans has been qualitatively different from that of any other racial or ethnic minority in the United States" [33]. Additionally, we take a similar stance to El-Amin when she states "the systematic and deeply entrenched nature of racism in the U.S. context has been abundantly covered and descriptively and empirically written about. As such, this work assumes that the reader knows that the United States as it currently stands both sits in and promotes racist ideology, beliefs and subsequently creates and sustains racist individuals" [15]. The five pillars of the liberation framework are: (1) sound racial identity, (2) critical consciousness, (3) collective obligation, (4) liberation centered academic/achievement identity, and (5) activism skills (see Figure 2-1). It is impossible to use computing to transform society without addressing these five pillars. I discuss how the liberation framework extends the literature about educational theories that focus on transforming society. Although there are curricula that individually incorporate some of these liberation tools [36, 31, 34, 46], liberatory computing draws attention to the importance of incorporating all of these tools. El-Amin illustrates "how all of the pillars in this educational framework are intricately interwoven and none of them can work alone to ensure the desired result" [15]. Educators can pragmatically teach African American students how to combat institutionalized oppression while centering the African American experience. In Figure 2-2, we present goals and objectives for a data activism curriculum in relation to liberatory computing.

Current computing curricula for minoritized students focus on making computing culturally relevant by incorporating social justice, music, and sports, and other topics students find interesting into lesson plans [16, 44, 27, 36, 6, 9, 17, 42, 29, 32].

However, typical computing curricula do not ensure that students have the advanced computing skills to take action against injustice. Meanwhile, there are computing curricula that give students the freedom to choose a project of interest [20, 29], but they do not encourage students to focus on social justice topics. The data activism curricula encourage students to use their advanced data science skills to make real-world contributions in support of minoritized groups. As bell hooks states, "The classroom remains the most radical space of possibility in the academy... Urging all of us to open our minds and hearts so that we can know beyond the boundaries of what is acceptable, so that we can think and rethink, so that we can create new visions..." [26]. By incorporating an activist lens in computing curricula and pedagogy, the computing field will attract more African American students and pave paths toward social impact.

2.1.1 Sound Racial Identity

According to El-Amin, a sound racial identity plays a crucial role in helping African Americans recognize that stereotypes about their racial group are often inaccurate [15]. In addition, it is essential for African American students to understand how their racial identity shapes their experiences, self-perception, and how they are perceived by others [7, 50, 43, 42]. Figure 2-3 illustrates the components of a sound racial identity, which include high private regard, low public regard, and high centrality. High private regard involves having a positive attitude towards one's racial group, while low public regard acknowledges the negative societal attitudes towards that group. High centrality refers to the significance of one's race in shaping their overall identity [15].

It is evident that the current approach in computing education does not adequately address the three subcomponents of having a sound racial identity that are specific to the experiences of African Americans. Although culturally relevant-sustaining computer science, culturally responsive computing, and critical computational literacy have emerged as approaches to enhance the computing self-efficacy of underrepresented students [34, 46, 31], they do not explicitly incorporate all three components

required for a sound racial identity that is tailored to the unique experiences of African Americans. Furthermore, these aforementioned frameworks do not offer adequate protection against the psychological effects of racism that African Americans experience. Additionally, incorporating students' cultural wealth is a central aspect of developing a sound racial identity in high school computing programs [35]. However, it is important to note that possessing a sound racial identity alone does not automatically ensure the ability to critically examine and dismantle hidden systems of oppression, as emphasized by El-Amin [15].

2.1.2 Critical Consciousness

Paulo Freire defined critical consciousness as the capacity to acknowledge, resist, and analyze systems of inequality (see Figure 2-4). The first component of critical consciousness is critical reflection, which involves the ability to scrutinize power dynamics in both personal and societal contexts. Another crucial aspect is critical action, which entails taking steps to challenge oppression. Also, Freire introduced the concept of praxis, which involves the integration of critical reflection and critical action and is crucial for effectively combating systemic oppression. Furthermore, it is vital to have a sense of agency, which reflects one's level of confidence in their ability to address systemic oppression and make a positive impact.

Students need to understand the roots of their oppression before they can change the source of their oppression. To control the narrative is to control the power. Critical consciousness is essential to effectively ending racism, but it is not enough because it is achieved through having a sound racial identity [15]. Culturally relevant pedagogy and critically conscious computing recognize the importance of students' knowledge in critical consciousness and computing, as it enables them to understand and analyze how computing can potentially perpetuate the oppression of certain groups [12, 1, 31, 35]. However, critical consciousness is not enough to transform society because it "doesn't define that action explicitly as collective" and it could be used for "purely individual ends" [15].

2.1.3 Collective Obligation

Since the beginning of slavery, fear of uprisings led to laws that punished and killed African Americans for gathering. Separation was subconsciously ingrained into African Americans by house slaves receiving "better" treatment than field slaves when they were both slaves [2]. As a result, many African Americans believe they have to compete against one another in order to accomplish their goals. The concept of collective obligation consists of two key components: group identification and group consciousness [15]. Group identification refers to the degree to which an individual identifies themselves as a member of a particular group. On the other hand, group consciousness encompasses three critical elements: the recognition that the group is disadvantaged in terms of power, the rejection of societal justifications for this disadvantage, and the belief that pooling resources can help overcome barriers (see Figure 2-5). According to El-Amin, African Americans must believe in linked fate, which is the concept that one person is not free until everyone is free [15]. Empowering African American students to advocate for themselves and their communities in the field of computing fosters significant systemic change.

Although the literature on broadening participation in STEM does not explicitly mention collective obligation specifically for African Americans, previous research papers do emphasize the importance of community engagement [27, 28]. Culturally relevant-sustaining computer science education incorporates the importance of including diverse groups of people in a class setting [12]. However, collective obligation requires understanding the source of their groups' oppression while having a sense of responsibility for their community.

2.1.4 Liberation Centered Academic/Achievement Identity (LCAI)

According to El-Amin, it is essential for educators to be unwavering in providing African Americans with positive affirmations regarding their racial group's academic competence, just as society relentlessly presents negative messages [15]. The Liberation Centered Academic/Achievement Identity (LCAI) empowers African Americans

to recognize that their academic success can be utilized to combat racism both for themselves and their community. The two subcomponents of LCAI are an Embedded Achievement philosophy and the Achievement for Freedom philosophy (Figure 2-6 and 2-7).

The Embedded Achievement Philosophy focuses on fostering a positive academic self-concept specifically designed for African Americans, aiding them in dispelling myths of intellectual inferiority [15]. The Achievement for Freedom Philosophy embodies the belief held by students that their educational accomplishments should be utilized for the purpose of collective transformation [15]. It is common for African Americans to experience discrimination in STEM classes regarding the stereotype that African Americans are not scientists [27], especially African American women [8]. As a result, one of the tenets of culturally responsive computing is that "the learning context supports transformational use of technology" [46]. However, culturally responsive computing does not intentionally assist African American students with resisting the pervasive messages. Essentially, an increase in African Americans in computing does not necessarily benefit African Americans until they use their educational benefits to directly liberate other African Americans.

2.1.5 Activism Skills

In order to end systemic oppression, we must ensure that these activism skills are tailored specifically towards educating students about using computing as a "communication medium for activism" and using "technology as part of the activism" [25]. El-Amin identifies three domains of skill development essential for achieving racial liberation: a) activism techniques and strategies, b) technical activism skills, and c) socio-emotional capacities for activism [15]. Examples of cultivating activism techniques include building and leveraging influence, mobilizing people and resources, and raising consciousness. Technical activism skills encompass communication skills, collaboration skills, analytic skills, and technology literacy, which facilitate the effective planning and execution of activism strategies. Socio-emotional capacities for activism involve emotional reflexivity, managing destructive emotions such as anger, shame,

failure, and loss, cultivating critical hope, and sustaining love.

Computing curricula should be taught in a manner that leverages activism. Computational action, culturally relevant-sustaining computer science, critical computational literacy, and culturally responsive computing are examples of using technology to make an impact in people's lives [5, 34, 46, 35]. As depicted in Figure 2-8 and Figure 2-9, activism skills are essential to creating social change because they can enhance one's competencies in all of the five pillars through "knowledge of the problem, efficacy to fix the problem and a deepened commitment to the cause" [15]. There are several skills that students need to learn in order to be data activists, such as quantifiable action skills.

2.2 Critical Participatory Action Research

The final data activism project in the second data activism program, which will involve collaboration between students and community organizers, will be approached using the Critical Participatory Action Research (CPAR) framework. To begin with, we will discuss Participatory Action Research (PAR), which emerged as a research field in the late 1960s. The three principles of PAR are investigating a problem collectively, relying on local community knowledge to better understand the problem, and desiring to take individual and/or collective action to deal with the stated problem.

However, PAR projects do not focus on challenging systems of power. In contrast, CPAR was coined in 2012 and is a form of collective inquiry that provides youth and adults with opportunities to identify problems and possibilities in their own communities, gather and analyze data about these problems, and take action to create positive change. CPAR is an approach to research that centers democratic participation in each part of the research process [18]. Projects are built on the assumption that what is seen as real has been shaped by social, political, cultural, economic, ethnic, and gender factors. CPAR projects investigate the social patterns that function as truths in people's everyday lives, and CPAR researchers strive to name and explore the different ways in which positionality, context, and power impact their findings.

In addition, this thesis incorporates principles of Youth Participatory Action Research (YPAR), which is an example of CPAR. YPAR "demands that we reconsider the why, how, and who of educational practice and research" [37]. YPAR dismantles the idea that students should only use their education to score high on standardized tests or that they do not possess enough knowledge to have a voice in what they should learn or in policy decisions. The "why" behind YPAR is to ensure that students use their academic and research skills to mitigate systemic oppression, not just for monetary benefits. Another important component of the "why" behind YPAR is to show adults that the purpose of research is to be critical of systems of oppression and take action against those systems. The "how" of YPAR prioritizes analyzing people's personal experiences with an issue rather than assuming that quantitative data can accurately capture people's everyday experiences with different forms of oppression, such as racism and sexism. The "who" of YPAR emphasizes the importance of respecting students' ideas about what they should learn and recognizing their power to determine what they should learn and how they should be supported. Essentially, "YPAR encourages young people to explode traditional ideas of knowledge production and use forms of creative expression to share what they know" [37].

The core of the CPAR process is built on relationship building, and in this study, both students and community organizations meaningfully engaged in the CPAR research process through activities and icebreakers that focused on building relationships (see Figure 2-10 and 2-11). After determining the research goal, students learned that creating a research question is an iterative process. They were introduced to the strengths and drawbacks of different methodological approaches to data collection, such as surveys, interviews, and literature reviews. In addition, students were taught how to collect and analyze data through thematic analysis. Finally, students confidently presented their research findings to a diverse group of stakeholders at prominent events such as the MIT Data Activism research symposium and the Harvard CPAR showcase. These stakeholders included community organizers, the Assistant Superintendent of Boston Public Schools, the founder of the Calculus Project, educators, researchers, as well as their families and friends. This empowering process

allowed African American students to realize that their ability to make a profound impact on society is not limited by age or dependent on a distant future.

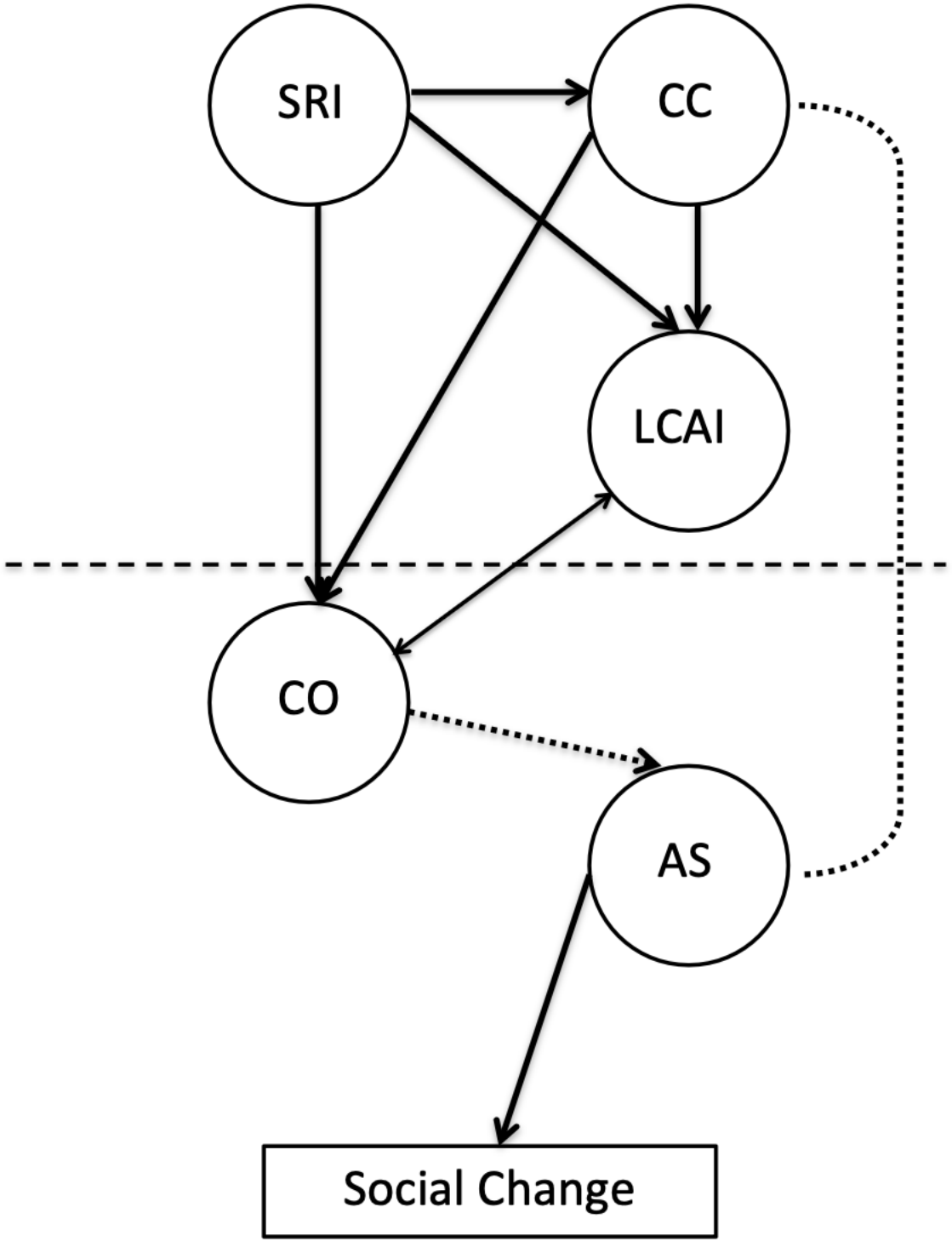


Figure 2-1: Data Activism Curriculum Goals and Objectives

TABLE I
DATA ACTIVISM CURRICULUM GOALS AND OBJECTIVES

Liberation Tools	Data Activism Curriculum Goals and Objectives
Sound Racial Identity: Students acknowledge how their racial identity shapes their experiences, self-perception, and how others perceive them.	**Intersectional Data Visualization:** Through visualizing data to describe their lived experience, students believe that race is an important part of their identity.
Critical Consciousness: Students understand the roots of their oppression so they feel a sense of urgency, which leads to action.	**Data Nutrition Label:** Students understand how computing can exacerbate systemic oppression, and learn how to explain bias in a data set comprehensively and concisely.
Collective Obligation: Students understand how the experiences of their ancestors are connected to their communities' current struggles, and develop a sense of responsibility to their community.	**Paying It Forward:** Students create a data activism activity with the aim of strengthening connections in their community.
Liberation Centered Academic/Achievement Identity: Students recognize the importance of using their academic success to address racism for themselves and their community.	**Evocative Audits:** Through an arts based activity, students recognize that academic achievement is part of their racial identity despite the racism they and their ancestors experienced.
Activism Skills: Students explain the systems of oppression that need to end, and the new systems that must be built.	**Quantifiable Action:** Students incorporate the Design Justice Framework into an exploratory data analysis project that addresses systemic racism.

Figure 2-2: Data Activism Curriculum Goals and Objectives

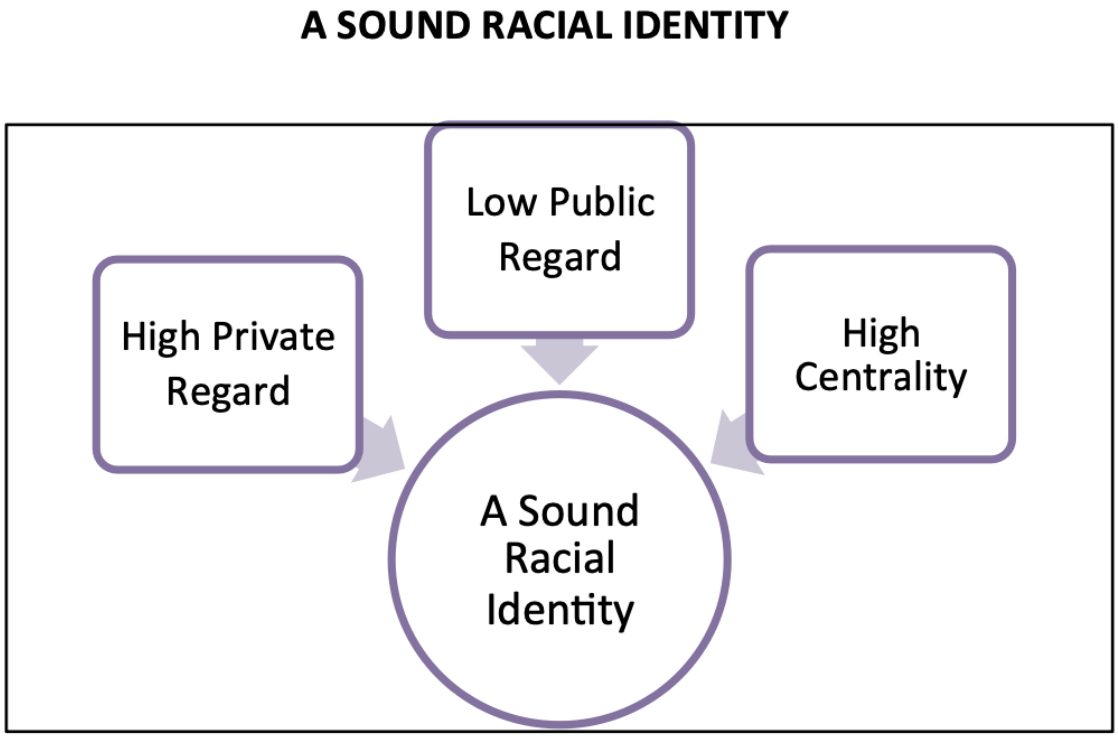


Figure 2-3: Components of a Sound Racial Identity from [15]

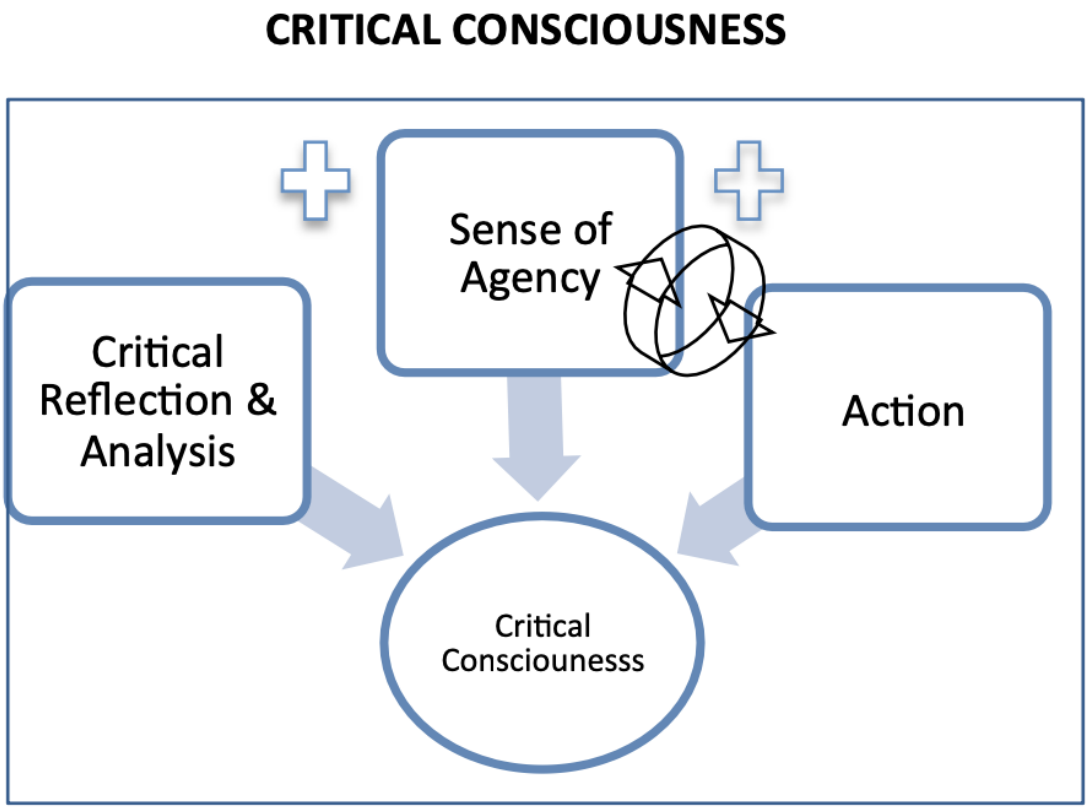


Figure 2-4: Subcomponents of Critical Consciousness [15]

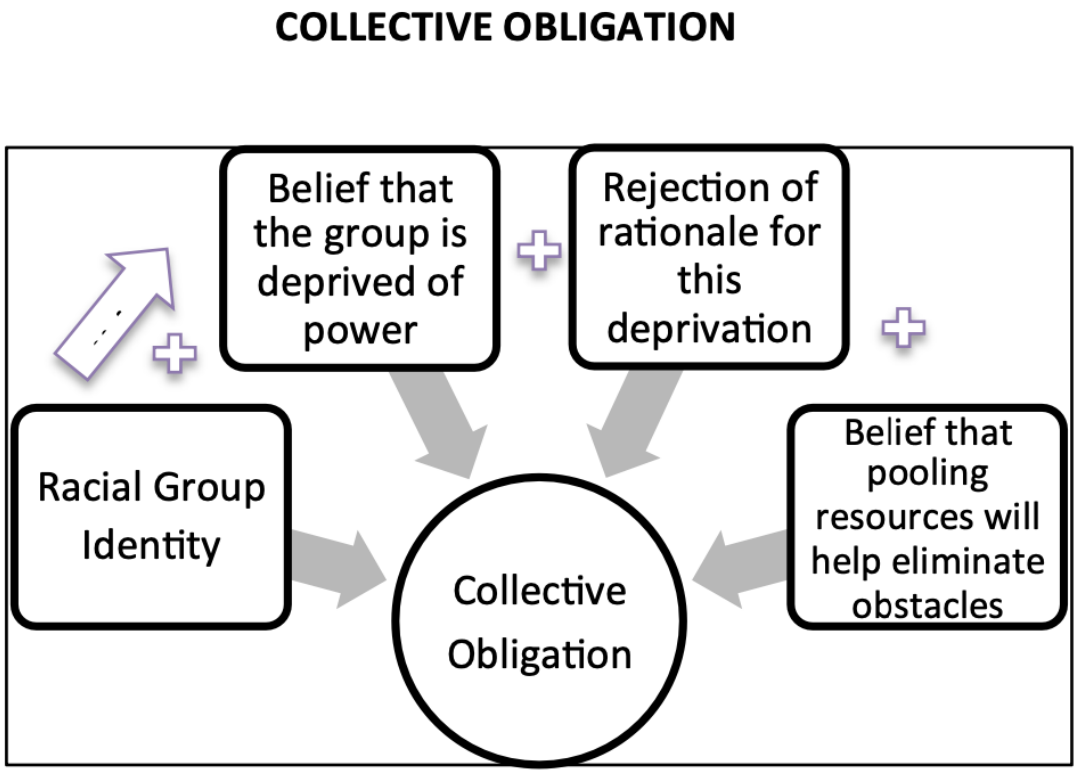


Figure 2-5: Subcomponents of Collective Obligation [15]

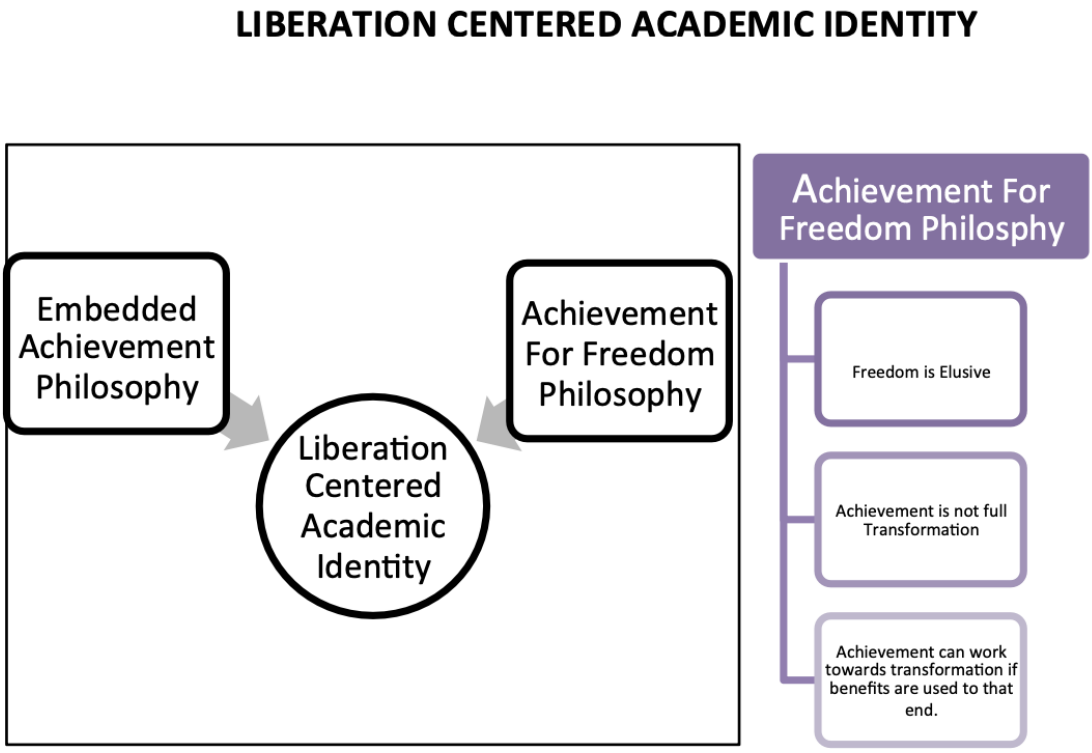


Figure 2-6: Subcomponents of Liberation Centered Academic/Achievement Identity [15]

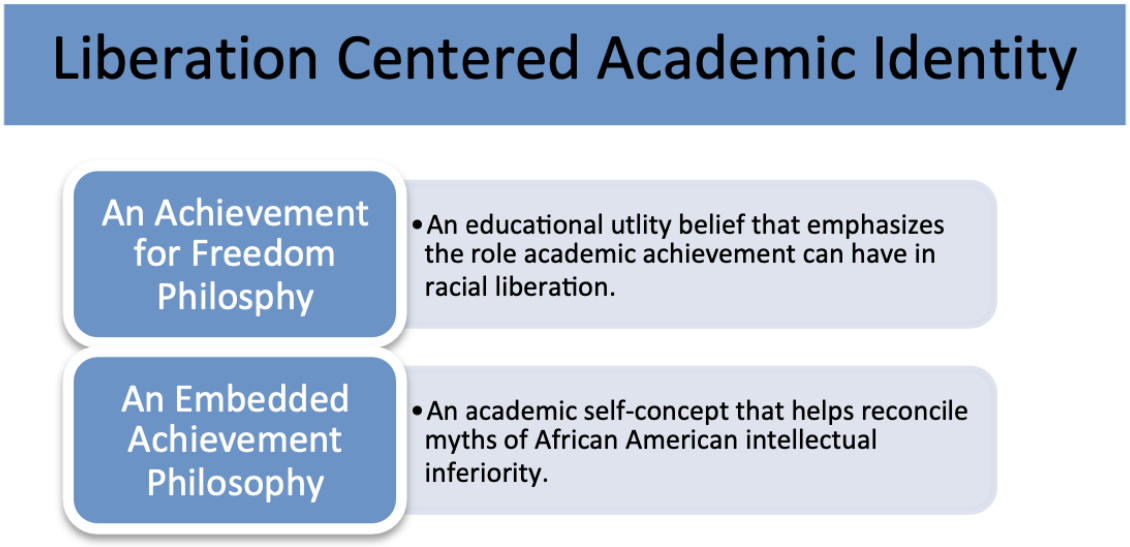


Figure 2-7: Relationship of each subcomponent to categories of an Academic Identity as described in the literature [15]

Figure 2-8: Context for Activism Skills Required for Transformation [15]

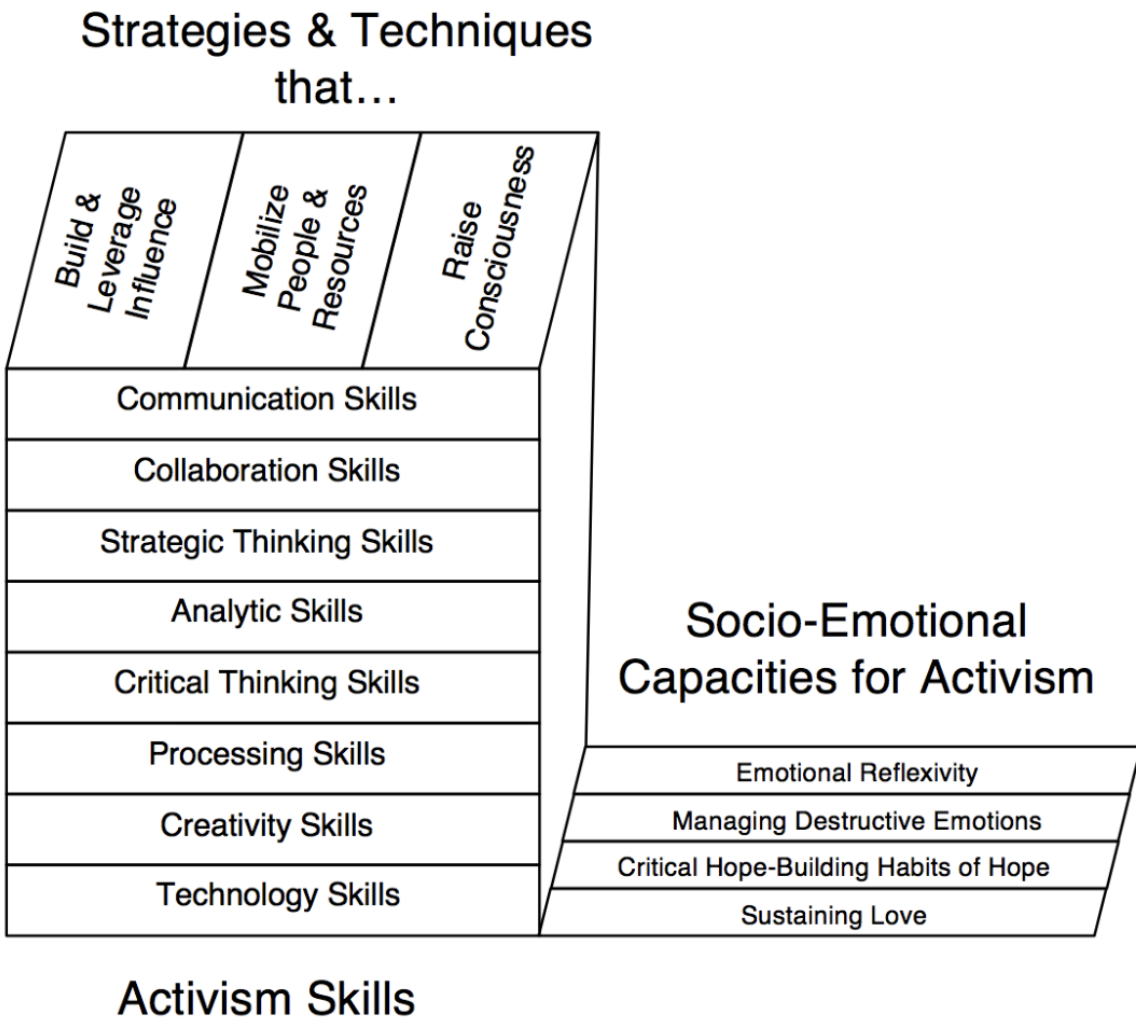


Figure 2-9: Suggested Domains of Skill Development For Racial Liberation [15]

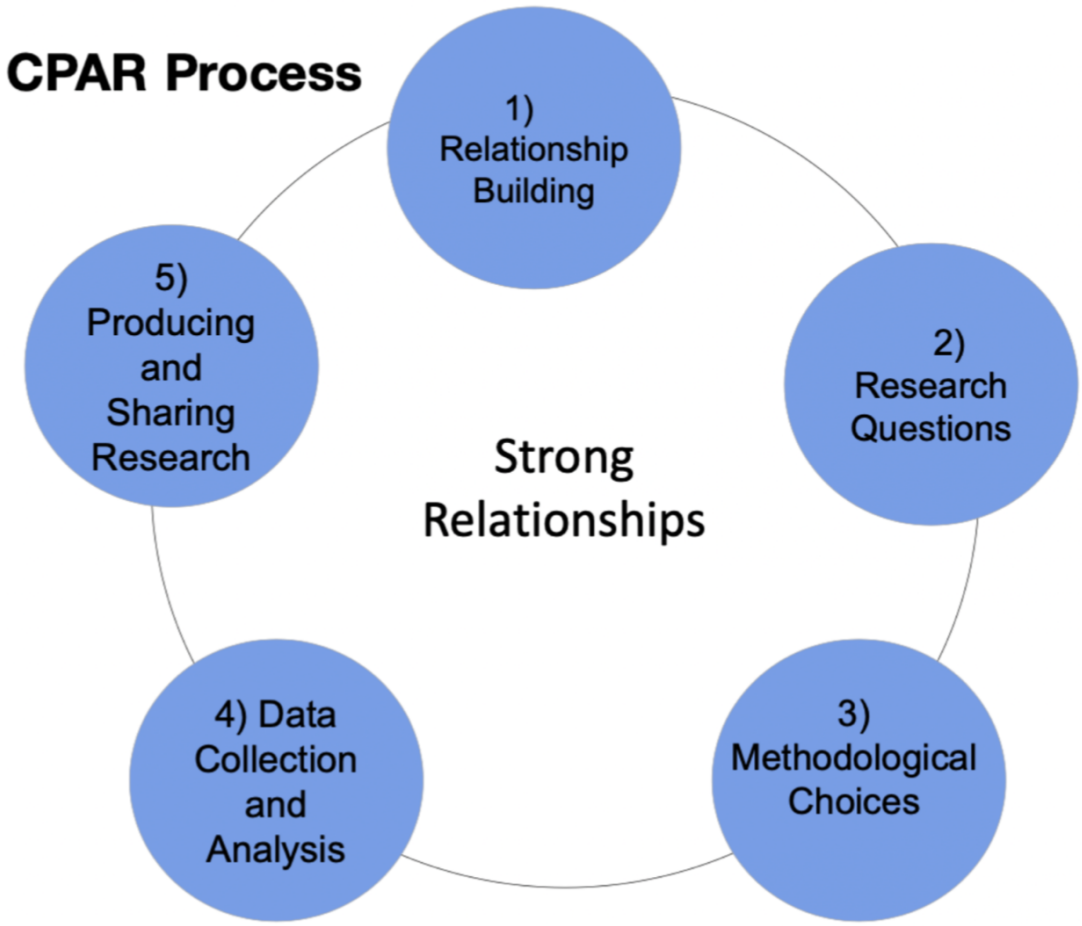


Figure 2-10: CPAR process

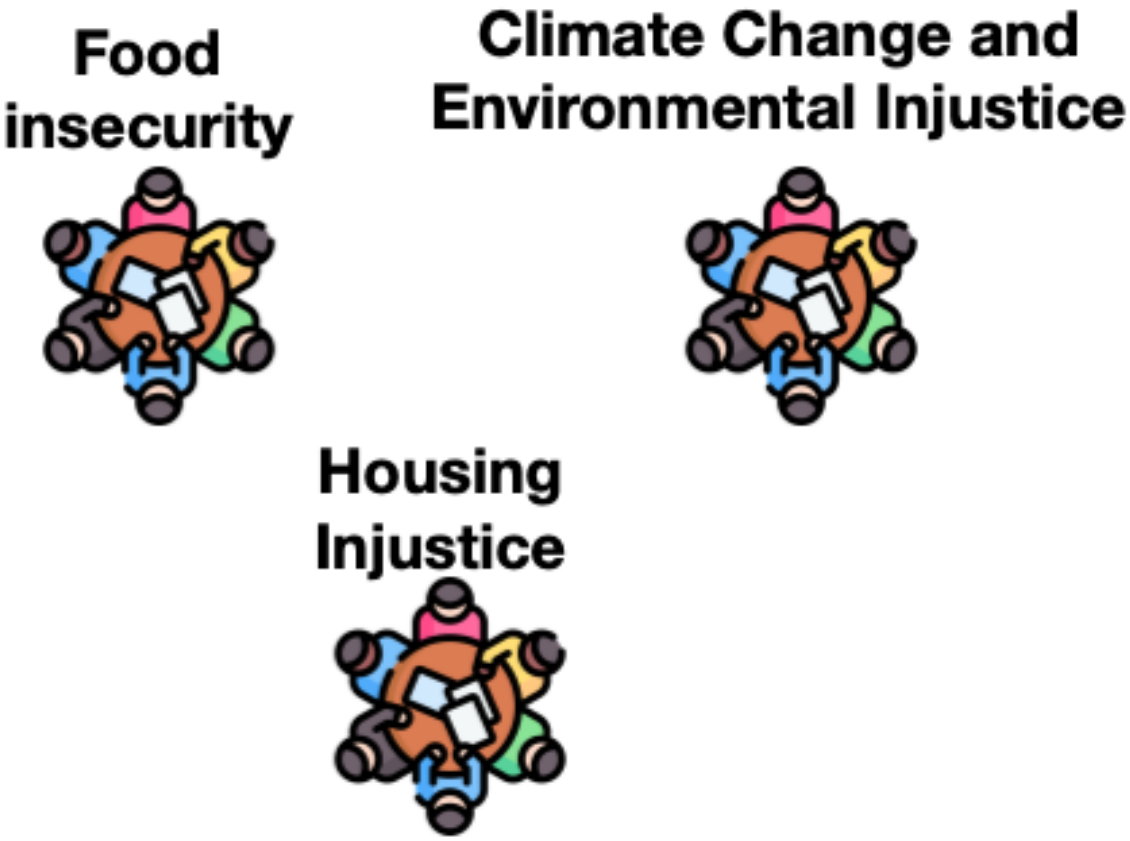


Figure 2-11: CPAR groups

3

Data Activism Curriculum Design with Cambridge Students

Chapter three serves as an illuminating exploration of the curriculum design behind the pioneering data activism program. It serves as a compelling example of a curriculum that empowers African Americans to unlock the vast potential of data science in dismantling power inequalities. The data activism curriculum is based on the principles of liberatory computing. This initial curriculum included a robust series of immersive lessons spanning over 90 hours. Participants in the first data activism program were selected from the Cambridge Mayor's Summer Youth Employment Program (MSYEP). Throughout the program, students watch the documentary "13th" to understand the historical bias in arrest data, and learn how to apply popular programming language, Python, and data analysis tool, Pandas. Afterward, they analyze

intersectional data on social justice topics such as food insecurity, gun violence, affirmative action, and diversity in entrepreneurship before analyzing the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) algorithm and presenting their findings to a non-technical audience.

Finally, the students undertake an independent capstone project that empowers them to conduct an intersectional data analysis aligned with their passions, aimed at supporting African Americans and other minoritized communities. In summary, the activities encompassed in the initial curriculum equip students with the necessary technical expertise and critical thinking abilities to effectively analyze data sets that are fraught with biases. To obtain a compilation of the curriculum topics and their corresponding learning objectives, please read the tables that were created by Olivia Dias: 3.1, 3.2, and 3.3.

3.0.1 Intro to Data Activism

The objective of this assignment was to familiarize students with the concept of data activism and its various dimensions. Students acquired a comprehensive understanding of the multifaceted role of data activism, incorporating the following key aspects:

1. Analyzing power and how it operates in the world utilizing data
2. Challenging existing power structures through the use of data
3. Harnessing the synergy between art and computing to cultivate empathy and foster connections with individuals facing oppression

These assignments were designed to progressively enhance students' understanding of power dynamics in society and how data can be utilized to challenge systems of power. The introductory activity revolved around an analysis of power dynamics and their profound impact on individuals, with a particular focus on the examination of how AI algorithms can perpetuate gender and racial biases. To facilitate this, students were assigned to watch Dr. Joy Buolamwini's thought-provoking spoken word poem, "AI, Ain't I A Woman," which effectively highlighted this issue. Following the video,

students engaged in reflection using the 3,2,1 framework. They were encouraged to share three facts they learned from the video, two facts they were previously unaware of, and pose one question they have after viewing the content. This reflection exercise was conducted on a dedicated discussion board platform, such as Padlet. The primary objective of this assignment is to raise awareness regarding AI bias and foster students' comprehension of how power dynamics can manifest in subtle ways.

The second activity builds on the first by introducing the concept of challenging power with data. Students engaged in a thought-provoking video titled, "How one journalist risked her life to hold murderers accountable - Christina Greer," which shed light on the inspiring story of Ida B. Wells. This video showcases Wells' remarkable efforts in collecting and analyzing data to champion justice and hold accountable those responsible for the lynching of African Americans. The 3,2,1 framework is used to help students reflect on what they learned. The purpose of this assignment was to show students how data can be used as a tool to challenge power and bring about change.

The third activity introduced students to the powerful combination of art and data as tools for cultivating empathy towards oppressed individuals. Students watched a video titled "Bryan Stevenson, Lester Holt Revisit A Painful Past To Create A Better Future | NBC Nightly News," which offered a profound exploration of Bryan Stevenson's National Memorial for Peace and Justice. This memorial stands as a solemn tribute to the enduring legacy of enslaved African American people and the painful history of lynching. The museum features impactful sculptures and installations that symbolize the victims of lynching, evoking a deep emotional response. To encourage reflection and consolidation of knowledge, the 3,2,1 framework was incorporated into this activity.

This assignment fostered students' understanding of how art can serve as a catalyst for empathy and effect meaningful change. Overall, these assignments helped students understand the different aspects of data activism. By the end of this lesson, students gained a deeper understanding of data activism, which incorporates the analysis of power dynamics and its manifestation in our society through data. In ad-

dition, they learned how data can be wielded to challenge prevailing power structures. Furthermore, they explored the powerful combination of art and computing.

3.0.2 Intro to Python and Pandas

During this lesson, students delved into the fundamental concepts of Python and Pandas, gaining insights into data analysis. Additionally, they explored the application of Pandas within the domain of food insecurity. To reinforce their understanding, we employed Deepnote, an interactive online platform, enabling hands-on practice of these skills.

3.0.3 Intersectional Data Analysis of Food Insecurity in Cambridge

This section was authored by Sophia Brady, one of my undergraduate researchers, who also developed the lesson. Given historical discriminatory practices such as redlining, we reasoned that analyzing racial discrepancies in accessing healthy food would be a relevant social justice issue to analyze and challenge in the local community. As the project involved students exclusively from Cambridge, our analysis naturally focused on examining the surrounding neighborhoods of the city.

The dataset used for analysis was the U.S. Department of Agriculture's Food Access Research Atlas. The dataset provides an assigned metric called the mRFEI index for each census tract in the U.S., which measures the ratio of healthy food to unhealthy food within that tract. Higher indices indicate better access to healthy food, while lower indices indicate higher access to unhealthy food. A score of zero indicates a food desert, representing a lack of access to food in general within the area. The purpose of the students' analysis was to understand how, by way of systemic oppression, race and class impacts food accessibility outcomes within Cambridge.

To begin, the students were introduced to the concept of food insecurity. As the dataset contained detailed information on both food deserts and food swamps (areas with limited access to healthy food but abundant access to unhealthy food), our

primary emphasis was on exploring the correlation between food insecurity and geographic location. Next, the students learned about food deserts and swamps. Then, the students learned about how practices such as redlining, that largely deprived communities of color of their wealth, have contributed to the formation of food deserts and food swamps. We encouraged the students to highlight the inequalities that exist in accessing healthy food and challenge systemic oppression through their intersectional data analysis on Deepnote. Additionally, we reminded the students that geography is just one factor that plays a role in food accessibility, and that there are oftentimes many metrics to use when studying a complex issue.

During the intersectional data analysis, the students used Python and Pandas to analyze the racial and economic demographics of food deserts and food swamps in Cambridge. First, the students cleaned the dataset by removing null values and making the dataset more comprehensible. Subsequently, utilizing boolean indexing techniques, the students discovered a notable disparity. They found that a higher percentage of low-income neighborhoods (48%) fell under the classification of either a food desert or a food swamp, compared to high-income neighborhoods (30%). To visually communicate this finding, the students created a pie chart.

After, the students conducted further analysis and discovered a concerning trend. They found that individuals belonging to minoritized communities, particularly people of color, were disproportionately affected by residing in food swamps within Cambridge. Specifically, they found that 19% of the Native Hawaiian and other Pacific Islander population, 14% of the Latinx population, 10% of the African-American population, 9% of the American Indian and Alaska Native population, and 8% of the Asian population lived in areas classified as food swamps. In comparison, only 5% of the Caucasian population resided in such food swamps. The students made a bar chart to present this finding. Building upon their analysis, the students further explored the efforts of local activists who are actively challenging food insecurity. This insight motivated and empowered the students to raise awareness about this pressing issue and take meaningful actions of their own.

3.0.4 Intersectionality Data Drawings

In this activity, students received an introduction to Python and intersectionality to engage with AI bias activities. They learned about intersectionality, which refers to the combination of multiple forms of discrimination, such as racism and sexism, and how it impacts a person's life experience. They watched a video titled "The Urgency of Intersectionality | Kimberlé Crenshaw," and answered questions related to the video.

Next, students used the "Feelings Wheel" to describe how the video made them feel and discuss what Kimberlé Crenshaw said that made them feel optimistic. They were then given an image titled "Pyramid of White Supremacy," which discussed different forms of white supremacy, and they discussed which statements negatively affected them or someone they knew (see Figure 3-1). The "Pyramid of White Supremacy" activity was created by Nathan Blumofe.

Subsequently, the students embarked on a creative endeavor by crafting a data drawing that vividly depicted their group's dataset or their own individual dataset. With a keen understanding of intersectionality, they explored the intricate interplay between various systems of oppression and how they impacted different facets of their identity. This artistic exploration allowed them to delve deeper into the nuanced connections between social inequalities and their personal experiences.

3.0.5 Discriminatory Design

In this activity, students learned about discriminatory design, which is the process of incorporating discriminatory values and assumptions into our technical systems. Examples of discriminatory design include standing benches in subway stations that deter people from resting or benches with armrests that deter homeless people from sleeping on them. To understand discriminatory design in everyday life, students watched two videos: "Why cities are full of uncomfortable benches (Vox)" and "From park bench to lab bench - What kind of future are we designing?" [47].

In addition, I led a book club twice a week after class for about 45 minutes where

Figure 3-1: Pyramid of White Supremacy: Adapted by the National Equity Project from Eilen Tuzzulo & Safehouse Progressive Alliance for Nonviolence

students and I discussed Dr. Ruha Benjamin's book titled "Race After Technology". To further explore the topic of discriminatory design, students worked in small groups of three-four people to answer the question: "What are some examples of discriminatory designs?"

Some answers provided by students were:

1. Many places don't take cash anymore because of COVID, so people without a credit card or bank account may have difficulty accessing goods and services.
2. Some events, such as sports games, require online ticket purchases, but not everyone has internet access, which can prevent some people from participating.
3. The Declaration of Independence's statement "all men are created equal" did not apply to African Americans because they were considered property.

Afterwards, students explained their answers to the class. We concluded the dis-

cussion about discriminatory design by reflecting on the following quote from Dr. Ruha Benjamin: "Those things dubbed 'just ordinary' are also cultural, as they embody values, beliefs, and narratives, and normal names offer some of the most powerful stories of all...and [are] infused with meaning and experience - particular histories, longings, and anxieties" [47].

3.0.6 13th

In this activity, students explored the historical bias in arrest data through the documentary titled, "13th". The documentary examined how systemic racism lead to the high rate of incarceration in America, and highlighted the impact of the 13th Amendment on the criminal justice system. First, students learned how categories of race were socially constructed as a method of controlling slaves and perpetuating the institution of slavery. Also, the video traced the evolution of racial hierarchy after emancipation. During the activity, students watched small video segments of the documentary and used the 3,2,1 framework. By exploring the historical bias in arrest data and the impact of the criminal justice system on minoritized communities, students gained a deeper understanding of the systemic issues that continue to affect our society today.

3.0.7 African American Achievements

The "African American Achievements" activity aimed to not only educate students about the remarkable accomplishments of African Americans in various fields but also to inspire and empower them to pursue their own aspirations. By highlighting these successes, the activity fostered a sense of pride in their own identity. To achieve this goal, students engaged in intersectional data analysis, analyzing two datasets that included over 300 African American individuals who made significant contributions in their respective fields. They created graphs to visualize and interpret the data, identifying patterns and trends that allowed them to gain a deeper understanding of the impact of African Americans in different areas.

The creation of a zine was one of the culminating activities of the "African American Achievements" activity. A zine is a self-published, small-circulation booklet or magazine that allows for creative expression and exploration. Students were required to research an African American individual who inspired their data activism and use that person's story as a basis for creating their zine. One of the students produced a zine highlighting the achievements of Dr. Willie Hobbs Moore, who became the first African American woman to earn a Ph.D. in Physics in 1972 (refer to Figure 3-2). The research undertaken not only offered valuable historical context regarding African Americans but also provided profound insights into the personal journeys of individuals. These insights served as a source of inspiration for the students, allowing them to reflect on and apply lessons learned from these remarkable stories to their own lives.

3.0.8 AI, Data Science, and Machine Learning

In the "AI, Data Science, and Machine Learning" section, students were introduced to the basics of creating an AI algorithm. The differences between AI, data science, and machine learning were explained to the students in a 10-minute presentation. AI was described as a set of algorithms that can make decisions with unforeseen circumstances. Machine learning was explained as an algorithm that learns about data and finds patterns or insights, and data science was defined as the process of analyzing and extracting relevant information from data. Then, the machine learning process was introduced, starting with the collection of data as the first step. Real-world data was explained to often have unorganized, missing, or noisy elements, and having a clean data set was said to help with the model's accuracy.

3.0.9 Class Imbalance

In this lesson, class imbalance was discussed as a way that algorithms can be biased. The concept of a class was defined as categories that the computer needs to learn, and class imbalance occurs when the training data is not evenly distributed

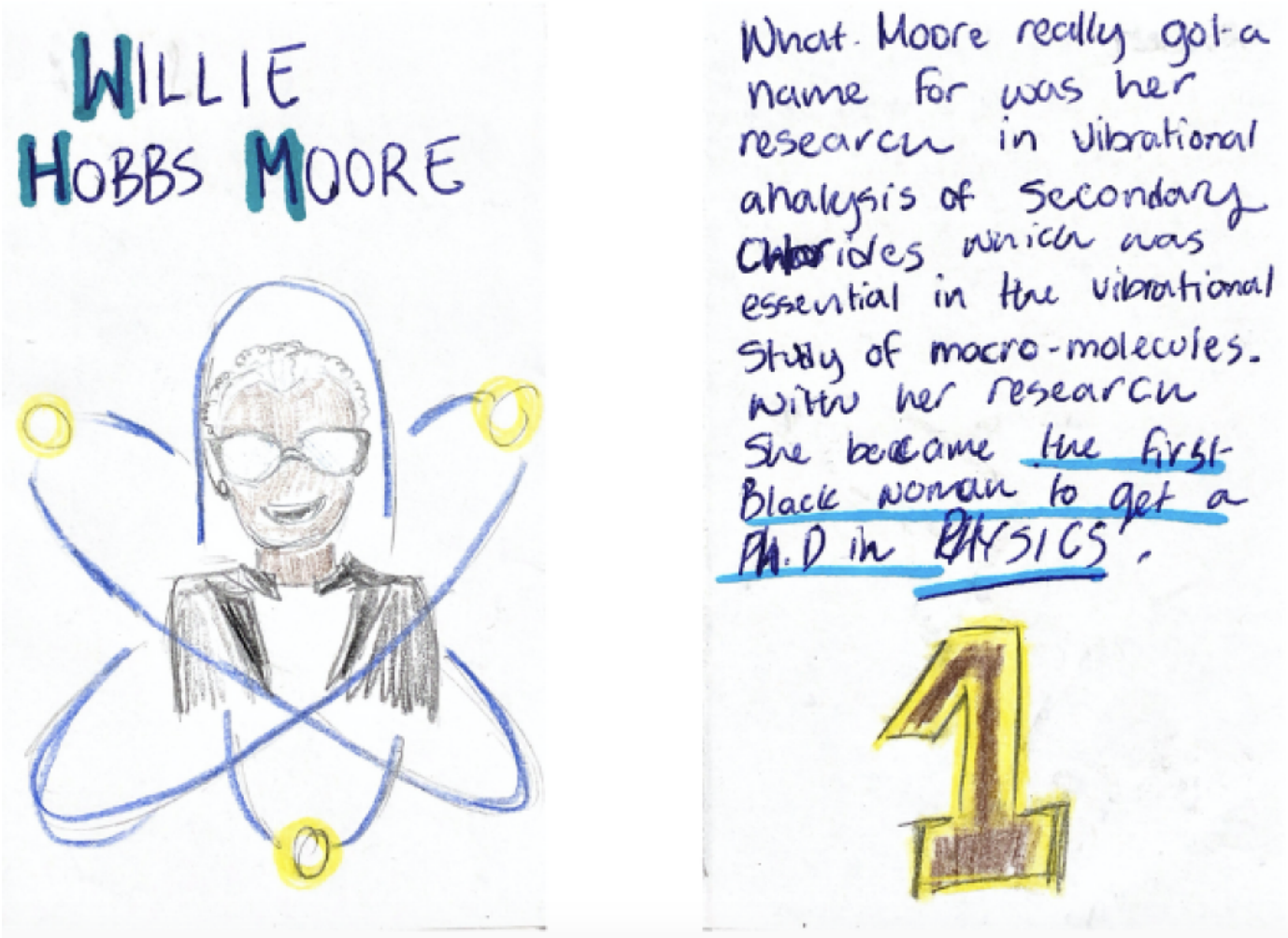


Figure 3-2: African American Achievements Zine

between classes, resulting in biased machine learning models. Dr. Buolamwini's research was cited, which revealed how some gender classification algorithms recognize individuals with deep skin tones less frequently than those with fairer skin.

To help students understand class imbalance, they created their own imbalanced algorithm using Teachable Machine, with two classes: smile and sad. The smile class had only two images of a smiling face, while the sad class had 40 images of a sad face. Students learned that an imbalanced dataset would result in inadequate representation of certain groups, hindering the algorithm's ability to discern patterns within those underrepresented groups. Lastly, they engaged in a conversation about whether AI is amplifying racism by watching a video from Vox titled "Are we au-

tomating racism?".

3.0.10 Introduction to Systemic Justice

One of my undergraduate researchers, Lina Henriquez, developed this activity. This activity centered around comprehending and addressing societal issues. The curriculum employed a unique framework known as systemic justice, which combined elements of systems thinking and design justice concepts.

The workshop commenced with an in-depth analysis of World Bank data concerning women, entrepreneurship, and legal frameworks. Students were encouraged to explore the World Bank's website, which provided economic insights into diverse systems influencing the success of women entrepreneurs. These systems contain factors, such as mobility, parenthood, and supportive laws. To enrich their understanding, students were given the opportunity to compare the United States with another country of their choice. Building upon this foundation, students then embarked on an intersectional data analysis, focusing specifically on women entrepreneurs in Boston. This allowed them to delve deeper into the intricacies of how different factors, such as race, ethnicity, and socioeconomic status, intersected to shape the experiences and challenges faced by women entrepreneurs in the local context.

The datasets related to women entrepreneurs lacked essential information about race, ethnicity, income, neighborhood, and other factors crucial for understanding racial disparities in women entrepreneurship in Boston. To address this gap, the students created vision boards to visually represent the missing information they would like to know in order to understand how to better support women that are not heavily represented in entrepreneurs. In addition to the data analysis, students used the systemic justice framework to analyze problems in their schools and understand the systemic issues underlying these problems. Throughout the activity, they realized the lack of accurate information in the datasets. To accurately depict the lived experiences of those affected by systemic inequalities and to co-design solutions, it is essential to have accurate and ethical data.

3.0.11 Racial Bias in COMPAS

During this lesson, we undertook a comprehensive exploration of the historical biases prevalent in arrest data. We recognized the significance of comprehending systemic racism within the criminal justice system to gain a profound understanding of how artificial intelligence (AI) systems can potentially amplify racism. Afterwards, we then introduced the COMPAS recidivism algorithm, which predicts the likelihood that someone in prison will commit another crime, and explained how ProPublica discovered bias in the algorithm. We highlighted how the algorithm incorrectly predicted that 60% of African American defendants would reoffend compared to 35% of Caucasian defendants, resulting in judges giving longer sentences to African Americans.

Furthermore, we used Glenn Rodriguez's story as an example to illustrate AI bias and its impacts on individuals. Rodriguez was deemed eligible for early release from his sentence after serving 26 years due to good behavior, but the COMPAS algorithm determined that he was at high risk for reoffending, resulting in him being forced to serve more time. This case showcases how AI bias can have a detrimental impact on a person's life, as the algorithm's prediction led to a longer sentence for Rodriguez, despite the judge's initial decision for early release.

Also, we explained how the COMPAS algorithm is trained on data from a questionnaire and how students acted as data scientists for Northpointe to determine which data should be used to train the algorithm. Then, we discussed how several questions in the questionnaire asked about prior arrests, which inherently introduces bias due to the systematically racist criminal justice system. Moreover, our discussions also encompassed two critical issues related to the COMPAS algorithm. Firstly, we examined the inherent biases present in the collected data, stemming from the historical biases within the policing and criminal justice systems. Additionally, we delved into the concern surrounding the utilization of a black box algorithm in COMPAS. This meant that the specific weighting and decision-making processes of the algorithm were known only to Northpointe, the company behind COMPAS. In con-

clusion, this lesson provided a thorough overview of AI bias and the negative impacts of biased algorithms in the criminal justice system.

3.0.12 Responsible AI Lifecycle

The purpose of this lesson was to emphasize the importance of responsible AI development and the potential for bias to be embedded into every step of the AI lifecycle. Students learned about the questions they should be asking themselves throughout the entire process to ensure that their AI models are ethical and unbiased. The lesson then reviewed the Responsible AI Lifecycle, including the key steps of getting data, cleaning and preparing data, training the model, and testing the model. Students were encouraged to consider ethical considerations and potential biases at each stage, and to ask critical questions such as whether the training data is representative of different groups, whether there are biases in labels or features, and whether the model is fair for all groups of people.

3.0.13 Intersectional Data Analysis of COMPAS

In this assignment, students analyzed an infamous AI algorithm, called the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) recidivism algorithm. In order for the students to analyze the COMPAS dataset, we taught them data cleaning and exploration. Data cleaning is the process of fixing or removing incorrectly formatted, duplicate, or incomplete data within a dataset. Data exploration is the process of exploring and visualizing the data to gain insights and determine patterns or trends from the dataset.

Students employed Python and Pandas to apply various fairness metrics to the COMPAS algorithm, with the aim of illuminating racial disparities in its outputs. They learned to utilize false positive parity, false negative parity, and demographic parity as fairness metrics to assess the algorithm's fairness, as these metrics effectively highlight the racial disparities present. Additionally, students successfully replicated similar findings to those uncovered by investigative journalists from ProPublica re-

garding the COMPAS algorithm. By doing so, the students gained a deeper understanding of the algorithm's impact on different racial groups.

3.0.14 Reenvisioning Data Science

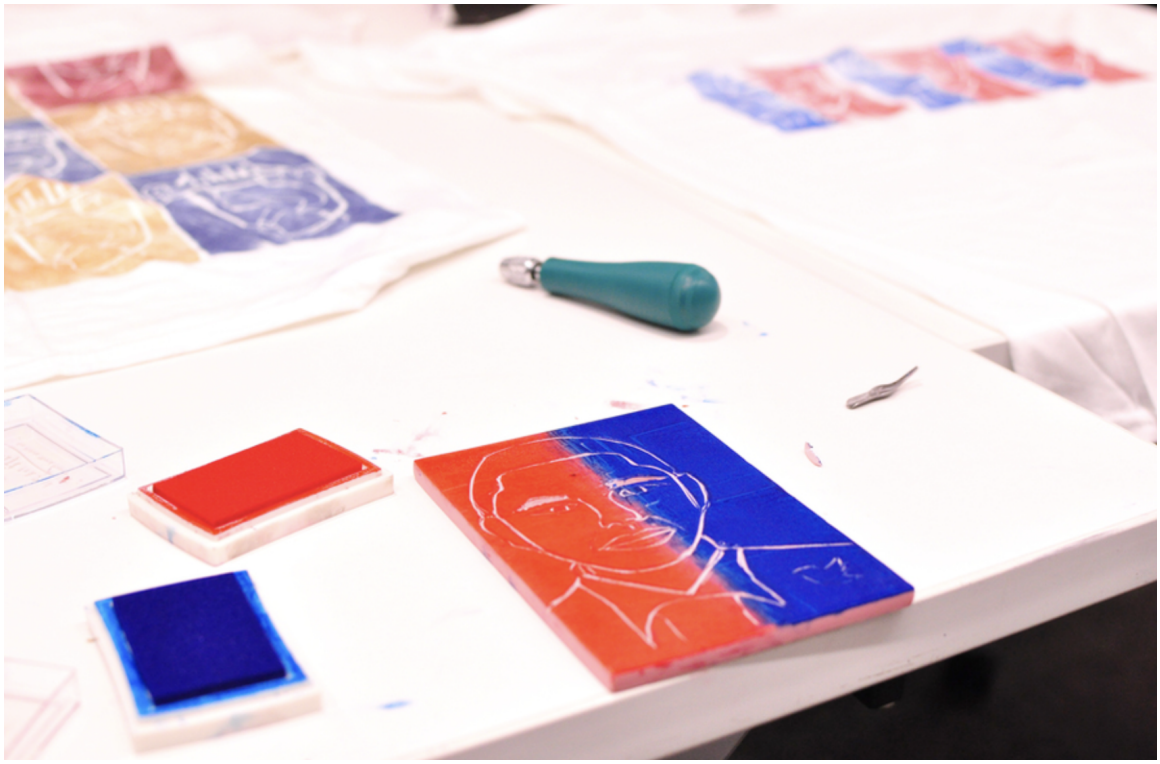


Figure 3-3: One of the students showcased their creativity by designing a rubber block stamp and using it to create a printed T-shirt featuring the image of former President Obama. Photo: Katherine Ouellette

The purpose of this activity was to explore how data science could be used to support minoritized communities and to encourage students to express their ideas through block printing (see Figure 3-3). Students created a block print design that answered the question, "How do you reenvision data science being used to support minoritized communities?" by using a carved material and an ink pad to print their design onto their shirt.

During the activity, students explored different ways people used data activism to support minoritized groups, practiced explaining how AI can exacerbate racism to non-AI experts, and explored artistic expression as a form of activism. Essential

questions that students considered included:

- Why is it important for individuals to develop a positive, healthy image of themselves?
- How can data science assist people?
- How can individuals discuss AI bias to non-experts?
- How did Nina Simone use her songs as a form of political protest to shape the objectives of the civil rights movement?

To answer one of the questions of the activity, students first listened to Nina Simone's song, "I Wish I Knew How It Would Feel To Be Free," and answered questions about its meaning and significance. Then, they reflected on their personal experiences of freedom and lack thereof, and considered how data science affected them or someone from their community negatively. Students were also given examples of how data science was not making people feel free, such as facial recognition not recognizing darker-skinned faces and predictive policing contributing to mass incarceration. Students then learned about how people were using AI and data science to support their community.

To create their block prints, students followed these steps:

- Drew their design onto sketch paper
- Transferred the design from the sketch paper onto the carving block
- Used the carving tool to carve the image
- Put the stamp pad on top of the block
- Transferred the block onto a shirt

Lastly, students shared their designs with the Mayor of Cambridge to spread awareness about the issues they had explored in this activity.

3.0.15 MIT List Visual Arts Center Gallery Visit

The purpose of this activity was to educate the students on the detrimental effects of AI and its potential to amplify racism, using art as a medium of expression. As part

of the activity, the students visited the "Matthew Angelo Harrison: Robota" Gallery at the MIT List Visual Arts Center. In this gallery, they explored a diverse collection of sculptures created by Harrison, an African American artist based in Detroit. Harrison's artwork prominently addresses the intersections of labor, technology, and cultural heritage. Following their examination of Harrison's sculptures, the students engaged in thoughtful discussions about the portrayal of forced labor and the negative implications of technology within his artwork. Moreover, they actively envisioned the possibilities of data science in assisting minoritized communities.

3.0.16 Intersectional Data Analysis on Affirmative Action

This section was written by Olivia Dias, one of my undergraduate researchers, who not only developed the lesson but also contributed to its content. The primary goal of this lesson was to enable students to develop data visualizations that would enhance their understanding of the insufficient diversity observed in colleges originating from states that have implemented bans on race-based affirmative action. The initial phase of the lesson concentrated on educating students about the significance of diversity within educational institutions. Students delved into the complexities surrounding the issue, allowing them to recognize the potential consequences that arise when colleges lack diversity, especially within the context of algorithmic decision-making processes.

During this educational session, students were introduced to the historical biases deeply embedded in the college admissions process, fostering a sense of critical consciousness regarding the topic of affirmative action. Through in-depth discussions, students explored the wide-ranging impacts of injustices such as the enduring legacy of slavery and poverty, and how these factors can significantly hinder an individual's access to higher education and financial stability. Furthermore, the students gained an understanding of affirmative action policies and their evolution over time, influenced by multiple legal challenges. They engaged in thoughtful conversations, exploring the complexities surrounding affirmative action and considering its implications in the realm of college admissions. In addition, the students delved into the topic of bias within college admission Automated Decision-Making (ADM) systems.

Through analysis and discussions, they examined the potential biases that can arise within these systems, contemplating the far-reaching consequences that such biases can have on equitable and fair college admissions processes.

In this particular activity, students explored a dataset to gain insights into the diversity within colleges, with a focus on whether they were situated in states that prohibited race-based affirmative action. The students were introduced to the concept of boolean indexing, a programming technique employed to filter and refine datasets by selectively extracting specific rows based on certain conditions. This technique was taught to the students to effectively clean and prepare the data for subsequent analysis and data visualizations.

3.0.17 Intersectional Data Analysis of Gun Violence in Boston

This section was authored by Zeynep Yalçin, one of my undergraduate researchers, who also developed the lesson. The purpose of this lesson was to teach the students about biased data in algorithms, which profoundly affect the lives of minoritized individuals, such as predictive policing or recidivism algorithms. Recognizing the profound impact these algorithms have on minoritized communities, the lesson created awareness about the presence of bias within these systems and the subsequent implications for minoritized individuals.

Firstly, students explored the intricate connections between racism, housing, and policing. The next phase of the lesson plan involved conducting an intersectional data analysis specifically focused on Boston shootings. The lesson focused on the detrimental impact of segregationist laws, which have led to the underfunding of communities of color. As a result of over-policing, these communities were disproportionately represented within the data set of shootings in Boston. By shedding light on this vital issue, the lesson plan raised awareness of the systemic factors that contribute to the overrepresentation of minoritized communities in incidents of gun violence and as targets of predictive policing.

3.0.18 Systemic Justice Capstone

The capstone equipped students with the skills to use data activism to support minoritized groups, such as African Americans. The objectives of the capstone included conducting background research on a systemic problem, finding a relevant dataset, and implementing an intersectional data analysis. In the first component, students were challenged to find a dataset that could mitigate the problem they had chosen, using free public database websites. The second component focused on conducting an intersectional data analysis. Students were expected to produce at least one data visualization that aided people in understanding the problem they were addressing. Additionally, they completed a data drawing to represent their data visualization to a non-technical audience.

Week	Lesson Topic	Learning Objectives
1	Intro to Data Activism | 4 hour	Learn about the components of data activism
1	Intro to Python and Pandas | 45 minutes	Learn the fundamental concepts of Python and Pandas, to gain insights into data analysis
1	Intersectional Data Analysis of Food Insecurity | 5 hours	Create data visualizations with Python and Pandas to analyze food insecurity in Cambridge
1	Intersectionality Data Drawings | 1 hour	Learn how data drawings can be more effective than traditional data visualizations in communicating systemic problems to a non-technical audience
1	Discriminatory Design | 2 hour	Learn about discriminatory design in everyday life
1-4	13th | 10 hours	Gain an understanding of the impact of mass incarceration on African Americans

Table 3.1: Learning Objectives for Data Activism Program with Community Organizations, Week 1

Week	Lesson Topic	Learning Objectives
2	African American Achievements Activity | 3 hour	Educate students about the remarkable accomplishments of African Americans in various fields in order to inspire and empower students to pursue their own aspirations
2	AI, Data Science, and Machine Learning | 90 minutes	Introduce the basics of creating an AI algorithm and understand the difference between AI, data science, and machine learning
2	Class Imbalance | 1 hour	Learn about class imbalance and discuss how algorithms can be biased
3	Introduction to Systemic Justice | 8 hours	Learn how to dissect problems and advocate for accurate and ethical data science and design processes
3	Racial Bias in COMPAS | 3 hours	Discuss the importance of understanding systemic racism in the criminal justice system to comprehend how AI can amplify racism
3	Responsible AI Lifecycle | 1 hour	Emphasize the importance of responsible AI development and the potential for bias to be embedded into every step of the AI lifecycle

Table 3.2: Learning Objectives for Data Activism Program with Community Organizations, Weeks 2 and 3

Week	Lesson Topic	Learning Objectives
4	Intersectional Data Analysis of COMPAS | 10 hours	Learn how to use false positive parity, false negative parity, and demographic parity to assess the fairness of COMPAS
4	Reenvisioning Data Science | 45 minutes	Explore how data science can be used to support minoritized communities and to encourage students to express their ideas through block printing
5	MIT List Visual Arts Center Gallery Visit | 2 hours	Explain the harms of AI and how it has the potential to exacerbate racism
5	Intersectional Data Analysis on Affirmative Action | 5 hours	Create data visualizations that will aid students in conceptualizing the lack of diversity in colleges from states that have banned race-based affirmative action
5	Intersectional Data Analysis on Gun Violence in Boston | 5 hours	Teach students how to understand and examine the systems of oppression that lead to biased data, and to use data science skills to create unbiased datasets, which may lead to fair algorithms
6	Systemic Justice Capstone Project| 20 hours	Conduct background research on a systemic problem, find a relevant dataset, and implement an intersectional data analysis

Table 3.3: Learning Objectives for Data Activism Program with Community Organizations, Weeks 4-6

4

Data Activism Program with Cambridge Students

In this chapter, I provide an in-depth exploration of the study design, participant demographics, class setting, and the methodology employed for data collection and analysis. Then, I show the qualitative analysis of the students' intersectional data analysis projects. Furthermore, the chapter presents the findings derived from a quantitative analysis of the students' pre- and post-surveys, offering valuable insights into the program's impact in increasing the number of students who possess the knowledge and skills to utilize data science in mitigating systemic oppression.

4.1 Study Design

This section provides an overview of the study design of the first data activism program with Cambridge students. The program involved multiple intersectional data analysis projects and an independent capstone project. The primary focus of this research study revolves around the following main research question:

> How do the data activism curricula prepare students to engage in data activism? Additionally, what is the impact of implementing different data activism curricula on students' proficiency in each liberatory computing pillar?

For the first data activism program, the specific research question is as follows:

> How does equipping students with skills to conduct intersectional data analysis on a systemic issue of their choice enable students' proficiency in each liberatory computing pillar?

To investigate the research questions, a mixed-methods approach was employed. Qualitative analysis focused on the students' intersectional data analysis projects, while pre- and post-surveys were administered to gather quantitative data on participants' perceptions of the program and their progress in adopting liberatory computing principles. The cohort consisted of 12 students who took part in the Mayors Summer Youth Employment Program (MSYEP) in Cambridge, dedicating four hours a day, four days a week to the six-week program at the Media Lab. Importantly, this study adhered to a rigorous ethical review process and obtained approval from the MIT Committee on the Use of Human Experimental Subjects (COUHES), underscoring its commitment to ethical standards. Additionally, all students and staff involved in the project underwent comprehensive research ethics training, ensuring the study was conducted with utmost ethical integrity.

4.2 Participants and Class Setting

During the summer of 2022, a six-week data activism program was conducted with students from the Mayor's Summer Youth Employment Program (MSYEP) in Cambridge, Massachusetts at the MIT Media Lab. The program involved the participation of 12 high school students, all hailing from Cambridge. Ten of the participants identified as African American, while two were Asian American. The recruitment of students was facilitated through the MSYEP program coordinators. Throughout the program, classes were held for four hours a day, four days a week, totaling over 90 hours of in-class activities and instructor-led discussions at the MIT Media Lab.

The program was primarily led by myself, overseeing most of the large group discussions, while undergraduate researchers took charge of facilitating various intersectional data analysis activities. Four undergraduate researchers provided assistance to students in completing their assignments. The majority of activities were conducted in small groups, with an undergraduate researcher or myself providing guidance, although a few lessons were conducted with the entire group.

4.3 Data Collection and Analysis

We conducted a comprehensive analysis of 12 students' assignments, which encompassed two intersectional data visualization activities, their final projects, as well as quantitative data derived from pre- and post-surveys. The program's effectiveness was evaluated through a combination of quantitative and qualitative analyses. A thematic analysis of three intersectional data analysis activities completed by the students revealed common patterns and themes. Additionally, the students responded to a series of 28 survey questions measuring their aptitude with various liberation tools and their preparedness to become data activists. The pre- and post-survey questions administered to the high school students are included in the Appendix. Throughout the research project, ethical considerations were of utmost importance, as evidenced

by obtaining written consent and assent from all participating students and their parents prior to data collection.

4.4 Results

This section highlights the findings of the 1st data activism program. Firstly, I will analyze the results of two assignments that led to the students' systemic justice capstone projects with MSYEP students. Then, I will examine the MSYEP students' final projects to understand how the program assisted them in integrating data activism into their lives.

4.4.1 Intersectional Data Analysis on Gun Violence in Boston

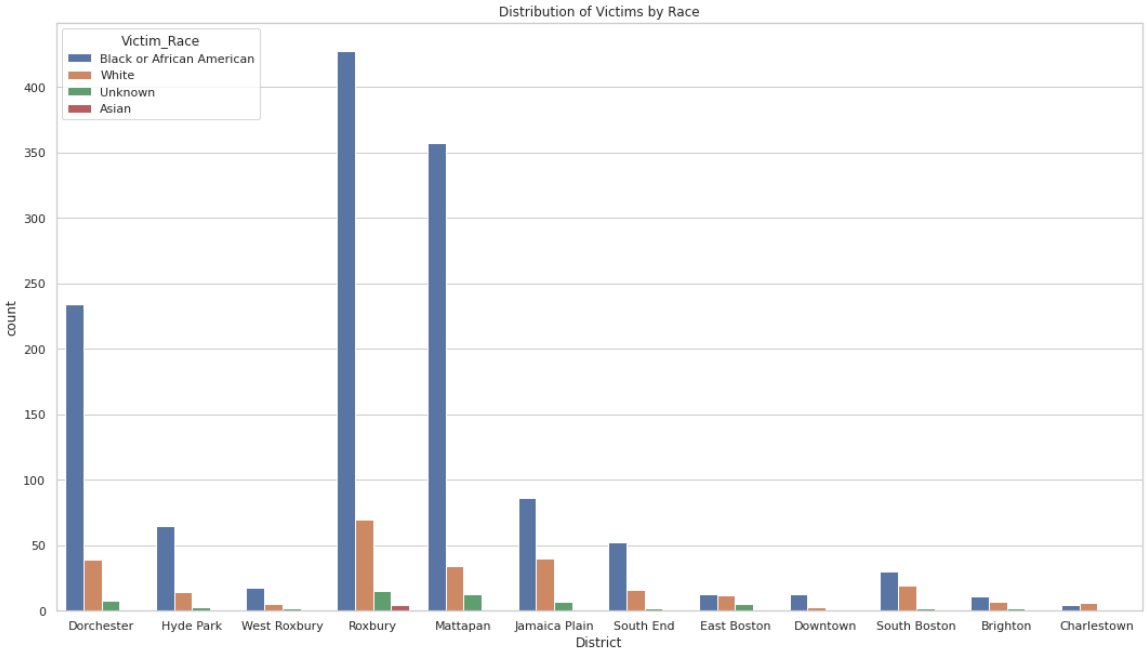


Figure 4-1: A bar chart that a student produced showcasing locations in Boston and race.

This section was authored by Zeynep Yalçin, one of my undergraduate researchers, who also developed the lesson. During this lesson, all 12 students were able to articulate how different forms of oppression contributed to racial disparities

in gun violence within the data set they analyzed in online discussion boards and classroom discussions. They also completed guided short-answer responses and data visualization tasks. To evaluate the effectiveness of this activity, we conducted a thematic analysis of how students applied the skills they learned from the intersectional analysis of the Boston shootings data set lesson to their final projects.

During classroom discussions and written responses about predictive policing, students demonstrated their understanding of the historical bias embedded in the data. Nine students discussed how different forms of racism led to bias in the Boston shootings data set. Next, every student conducted an intersectional examination of the data set in terms of race, gender, and location using Python functions to produce tables and bar graphs that highlighted the bias in the Boston shootings data set. Seven students created two bar graphs that showed the number of people from each race who suffered a fatal and non-fatal shooting (see Figure 4-1). One student connected their historical knowledge with the data visualizations they created by stating, "One of the main reasons why my data visualizations depict African Americans being the most negatively affected by gun violence is because of the over-policing of communities of color".

For the final project, seven students had the freedom to choose a topic of interest. Since some students chose to examine both housing and gun violence in their final projects for the data activism curriculum, the lesson engaged some students' unique interests. One student further studied gun violence while two other students completed projects that focused on housing accessibility. Moreover, two students utilized the table functions and comparison bar graphs, which were part of this lesson plan, demonstrating that students could apply their critical thinking and data science skills to their own projects. This assignment may further assist students in incorporating data activism into their everyday lives because students chose to research similar topics for their final projects that they believed would be meaningful to their community. The discussion posts and data visualizations students created showcased the effectiveness of this lesson plan, as students made a clear connection between housing, racism, and policing within the data set they examined.

4.4.2 Intersectional Data Analysis on Affirmative Action

This section, authored by Olivia Dias, one of my undergraduate researchers and the developer of the lesson, explores how students developed a critical consciousness regarding affirmative action and demonstrated their proficiency in data science by creating visualizations that highlighted the underrepresentation of minoritized groups in a college enrollment dataset. The lesson had active participation from a total of seven students. Each student showcased a strong understanding of the importance of affirmative action and demonstrated their acquired skills in intersectional data analysis, including techniques such as boolean indexing and the utilization of helper functions for data visualizations. In order to evaluate the effectiveness of this activity, a thematic analysis was conducted.

After completing the intersectional data analysis on affirmitive action, students were given the opportunity to apply their skills to a final project of their choice, focusing on a social justice topic. Among the students, six utilized boolean indexing, while two employed helper functions in their final projects. While this lesson primarily centered around racial disparities in college admittance, several students expressed interest in analyzing racial disparities in other domains. For example, one student chose to investigate the lack of diversity among students enrolled in Advanced Placement (AP) classes in high school (see Figure 4-2). Through this student's analysis, it was revealed that resource inequities resulting from funding disparities in school districts and unequal access to high-quality early childhood opportunities were significant factors contributing to educational disparities among minoritized groups.

4.4.3 Systemic Justice Final Projects

To evaluate the effectiveness of the final project, I completed a thematic analysis–finding common patterns and themes in qualitative data–of students' short responses and their data science skills. Seven students completed a final project. First, I evaluated how students used their autonomy to analyze a social justice topic of their choice. Students' final projects focused on one or more of the following categories:

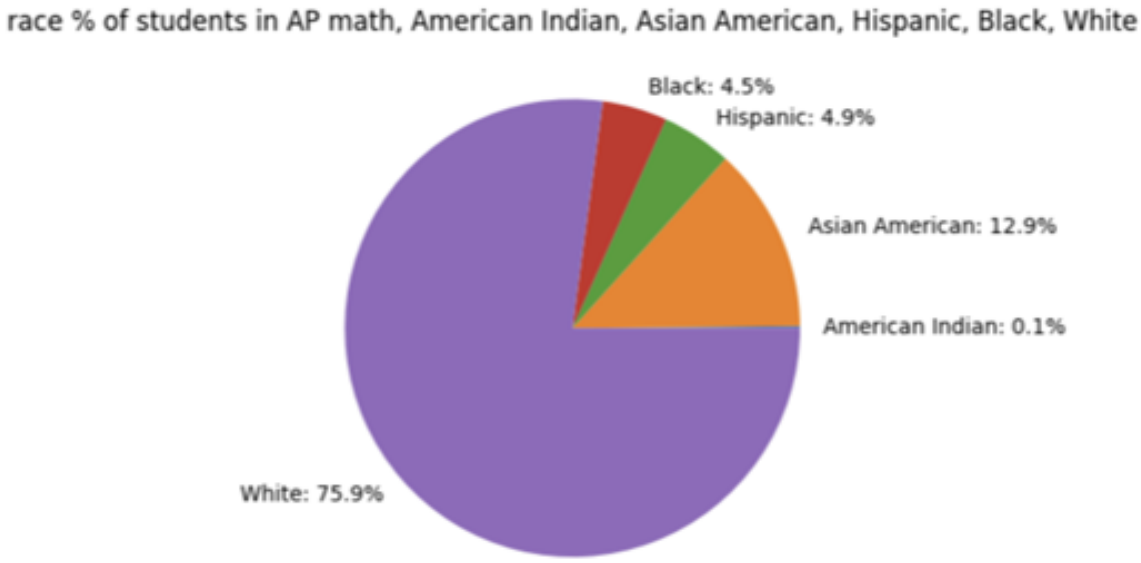


Figure 4-2: A student created an intersectional data visualization that illustrated the racial disparities among students enrolled in AP classes.

housing accessibility (two), climate change (two), quality education (one), gun control (one), racial disparities in healthcare (one), and poverty (five). This wide variety of categories demonstrates students' ability to apply data activism concepts to a topic they are passionate about and to identify injustice in many topics.

Next, I examined how students conceptualized the different forms of systemic oppression that may affect people in a certain minoritized group. Every project successfully discussed how racism contributes to harmful effects on African Americans. Students showed varying levels of understanding of the underlying structures affecting the problems they explored. While students' short answer responses varied from sophisticated to somewhat simplified, every student applied their knowledge of combating injustice and data science in their capstone project. As an example of a student who achieved a deep understanding of systemic racism and sexism in the healthcare field, one student described how racism contributes to low birth weights in African American women:

> Systemic racism causes psychological disorders such as depression and anxiety, which affects African American women for a long period of time. Racism especially affects pregnant African Americans because it causes

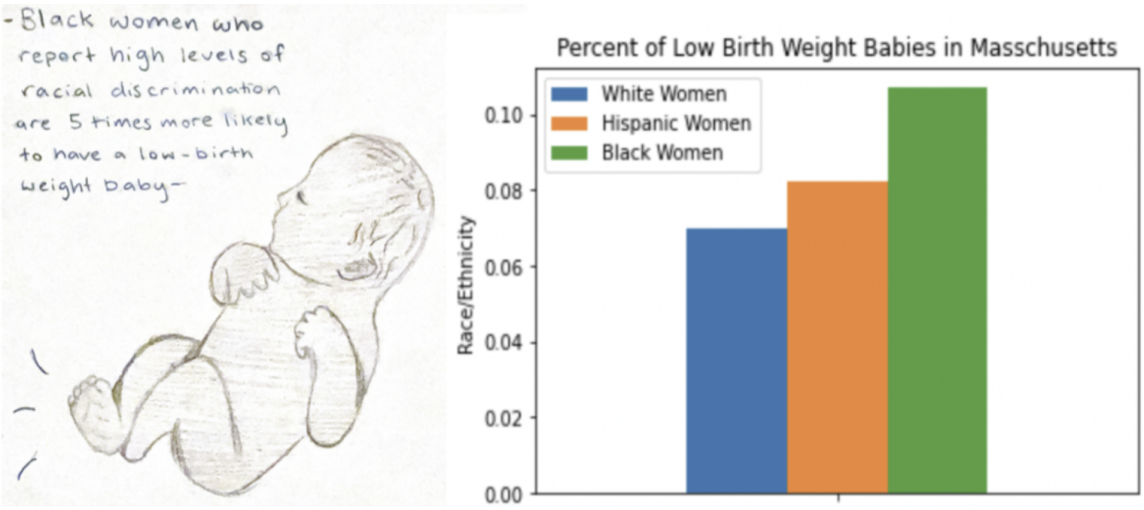


Figure 4-3: Student two developed an intersectional data visualization and corresponding data drawing that highlighted the racial disparities in low birthweight babies.

both harm to them and the baby.

Additionally, this student independently found a data set that highlighted this issue that they were passionate about mitigating, and produced meaningful data visualizations and data drawings to represent the low birth weight in African Americans (see Fig 4-3). In contrast, another student mentioned how the lack of gun control can negatively affect people that experience racism and ableism, but provided only a few facts to explain this statement due to the lack of time. Further attention to individual learning and more class time can enable all students to reach higher levels of understanding.

Afterwards, I analyzed how students utilized data visualizations to illustrate different systemic problems. In order to visualize the bias in their data sets, three students used pie charts, three used bar charts, and two used line charts. Also, students showed their understanding of how data cleaning and data mining are often the most time-consuming aspects of the data science development process (e.g. data mining, cleaning, visualizations, and modeling). The majority of their code consisted of data cleaning functions, with only a few lines of code to actually visualize the data. Students utilized all of the data cleaning and visualization functions that we taught them. In this study, I saw that students could apply these data activism skills in

the real-world. Through this systemic justice project, students identified a problem based on their unique lived experience, and used data science and their knowledge of intersectionality to analyze contemporary issues.

4.4.4 Pre- and Post- Survey Results

I administered a 28-question survey to nine students who completed the first data activism program. In this section, I will focus on eleven survey questions that align with different liberation pillars and explain how these questions assessed the students' preparedness to become data activists.

Sound Racial Identity

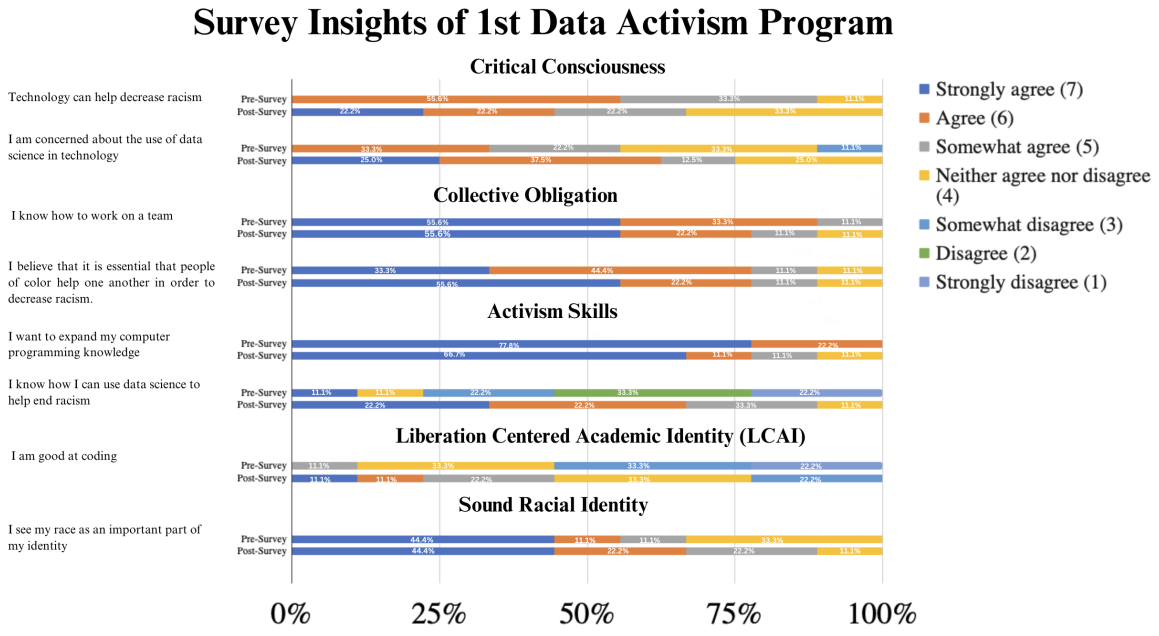


Figure 4-4: Survey Insights of 1st Data Activism Program

The focus of this section is to assess students' relationship with their racial identity, a crucial aspect in becoming effective data activists. A strong racial identity entails having a positive outlook towards one's racial group, recognizing negative societal attitudes towards the group, and acknowledging the role of race in shaping one's identity. This section presents findings from three survey questions concerning

racial identity.

Having a sound racial identity entails believing that race is a significant aspect of one's identity. The objective of this inquiry is to encourage students to acknowledge the importance of race as a fundamental part of their identity. One of the survey questions posed to the students requested them to rate their level of agreement with the statement "I see my race as an important part of my identity" utilizing a scale ranging from one (strongly disagree) to seven (strongly agree) (Fig 4-4). Following their participation in the data activism class, there was a 11.1% increase in students that agreed(one additional student agreed), and a 11.1% increase in students that somewhat agreed (one more student somewhat agreed) that race was a significant part of their identity. Before the program, 33.3% of students were neutral (three students were neutral about this statement). However, after completing the course, 11.1% of students remained neutral (only one student remained neutral) regarding this issue. Based on the findings presented in this section, the data activism class potentially exerted a positive influence on the students' perception of the profound role of race in shaping their identity. This conclusion is substantiated by the higher number of individuals who expressed a degree of agreement with this statement, signifying a notable shift in an aspect of their racial identity.

Another essential aspect of having a sound racial identity is having a positive outlook towards one's racial group. One question I asked in the survey was about the negative emotions students sometimes feel about being a member of their race, including feeling helpless, guilt, fearful, angry, or other (Figure 4-5). Students could choose more than one negative emotion. In the pre-survey, as indicated by the "Other" option, two students reported not feeling any negative emotions, one felt nothing, and one felt exhausted. In the post-survey, one student reported not feeling any negative emotions, two felt nothing, while one felt hopeless. Compared to the pre-survey, in the post-survey, two more students felt guilt about their race, and three students felt angry. However, there were six more instances of negative emotions expressed overall after the class ended.

Furthermore, the survey also included questions about positive emotions asso-

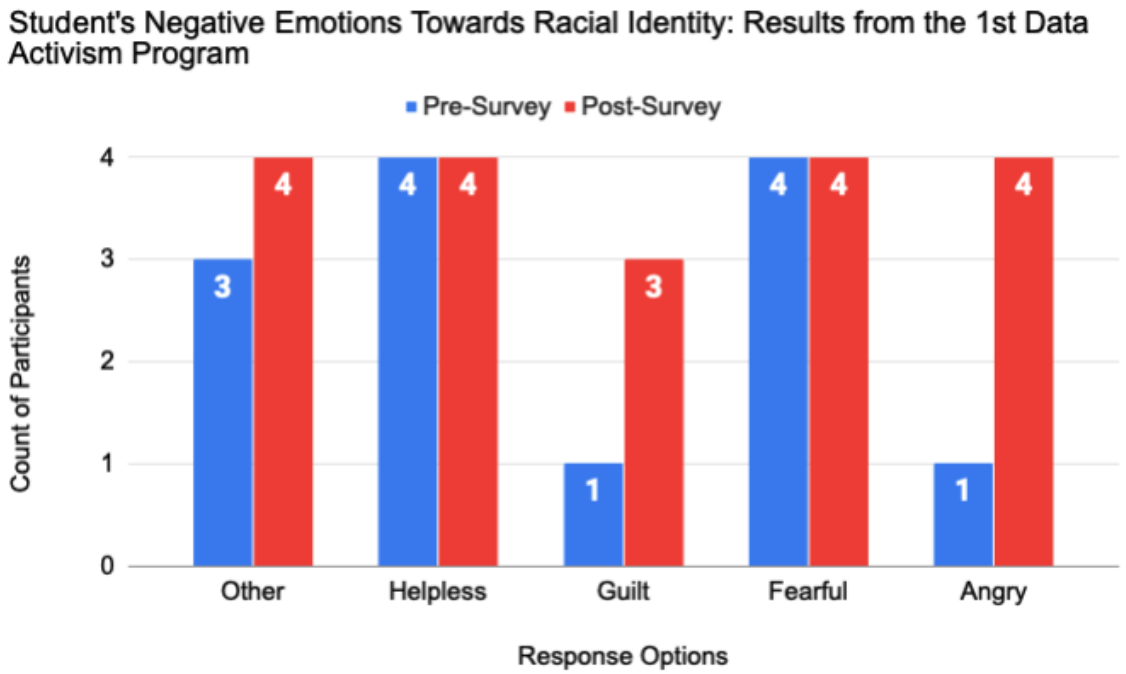


Figure 4-5: Student's Negative Emotions Towards Racial Identity: Results from the 1st Data Activism Program

ciated with students' racial identity, such as gratitude, pride, happiness, and awe (Figure 4-6). The results revealed that the same number of positive emotions was reported before and after the program. As a result, it is challenging to determine whether the data activism program increased the number of students who felt positively about their race. Nonetheless, a more extensive analysis, interviews, and a larger sample size are necessary to draw definitive conclusions.

It is probable that the data activism program had a positive impact on certain aspects of students' sound racial identity, such as increasing their awareness of racial issues through their "Systemic Justice" final projects and slightly improving their ability to acknowledge their race as a crucial aspect of their identity, as demonstrated by the survey results. However, it remains unclear whether the program led to an increase in positive emotions related to their racial identity, such as gratitude, pride, happiness, and awe (Figure 4-6). Therefore, further analysis with a larger sample size is required to draw more definitive conclusions. Overall, the data activism program could have enhanced certain components of their sound racial identity.

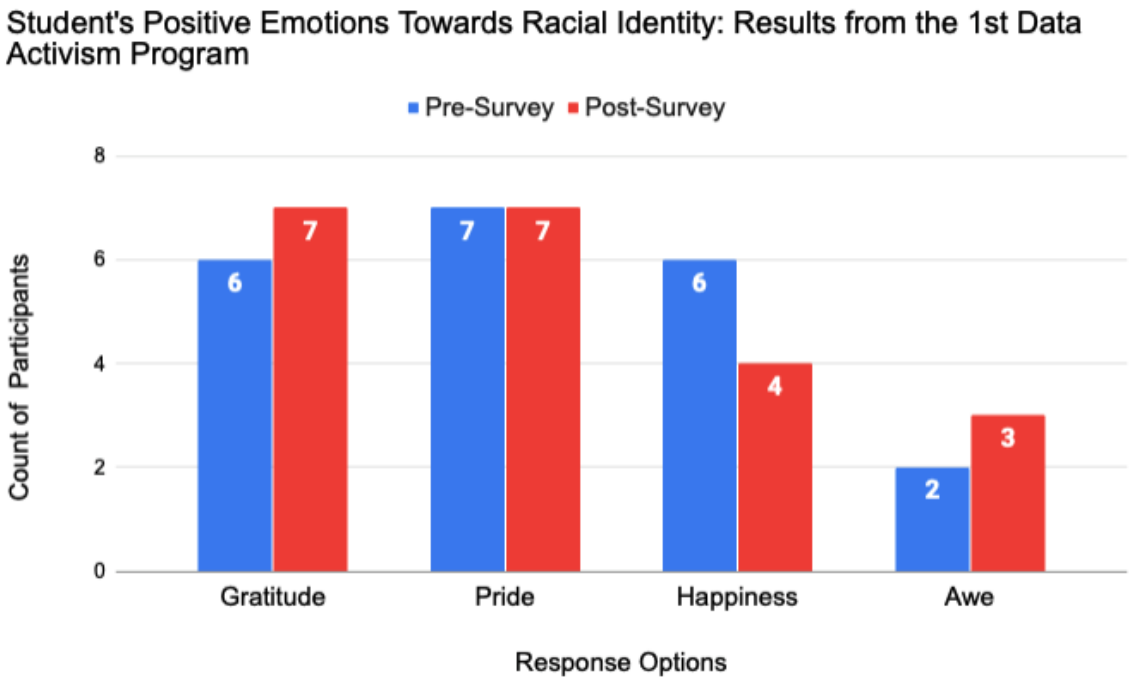


Figure 4-6: Student's Positive Emotions Towards Racial Identity: Results from the 1st Data Activism Program

Critical Consciousness

This section highlights the results of a survey that aimed to assess students' critical consciousness regarding racial justice. To effectively fight for racial justice, African Americans must possess critical consciousness and a clear understanding of the persistence of racism, as it is composed of three main components: critical reflection, sense of agency (self-efficacy), and critical action. In this study, students' critical reflection was evaluated through survey questions, while their sense of agency and critical action were assessed through interviews and projects.

One survey question aimed to gauge students' level of agreement with the statement "Technology can help decrease racism" on a scale of one (strongly disagree) to seven (strongly agree), as illustrated in Figure 4-4. Following the completion of the class, the results indicate a 22.3% decrease in the proportion of students who expressed agreement with the statement. There was a 22.2% increase in the number of students who strongly agreed with the statement, with two additional students joining this

category. The reason for the increase in students who neither agreed nor disagreed with the statement in the post-survey (representing 33% or three students) may warrant further exploration through follow-up interviews. This aspect holds importance as it could shed light on the underlying factors influencing students' perspectives. Furthermore, the observed rise in students who strongly agreed with the statement, alongside the increase in those who remained neutral, indicates a potential conflict some students face when reconciling the negative impact of AI on African Americans with their utilization of data science to develop projects aimed at mitigating systemic racism.

Another survey question asked students to rate their level of agreement with the statement "I am concerned about the use of data science in technology" on a scale of one to seven, as depicted in Figure 4-4. The results prominently demonstrate that following the completion of the class, there was a 25% upsurge in the proportion of students who expressed that they strongly agreed with the statement(two more students strongly agreed), and no students somewhat disagreed with the statement. This minor increase in the number of students concerned about the use of data science in technology suggests that the lessons on AI bias may have influenced some students to become more aware of how data science could harm African Americans. It also suggests that the study may have been effective in improving students' critical reflection on how systemic racism negatively affects minoritized groups and how it can lead to algorithmic bias.

Liberation Centered Academic Identity (LCAI)

To assess different components of having an LCAI, I asked students five questions. In this section, I will present the results from two of these questions. LCAI addresses two specific dimensions of African Americans' academic identity: "a) their academic self-concept, which refers to their beliefs about their ability to achieve and is cultivated through an Embedded Achievement Philosophy, and b) their educational utility beliefs, which refers to their understanding about the purpose of achievement and is cultivated through an Achievement for Freedom Philosophy" [15]. Overall, there was

a slight increase in the number of students who felt that they were proficient in coding and an increase in the number of students who recognized the potential of using their academic skills to address racism.

One of the survey questions aimed to assess students' self-confidence in coding skills, and the results revealed a slight increase in their confidence level. The question asked students to rate their agreement with the statement "I am good at coding" on a scale of one (strongly disagree) to seven (strongly agree), as depicted in Figure 4-4. It is gratifying to observe that, after taking the class, 44% of students expressed agreement with this statement to some degree, compared to only 11.1% who agreed with the statement before the class. These results indicate that some students felt that they were good at coding in as little as six weeks. However, a majority of students (three) remained neutral, likely due to their limited prior experience with Python. Nevertheless, it is encouraging to see that the curriculum has the potential to decrease the number of students who believe that they are not good at coding.

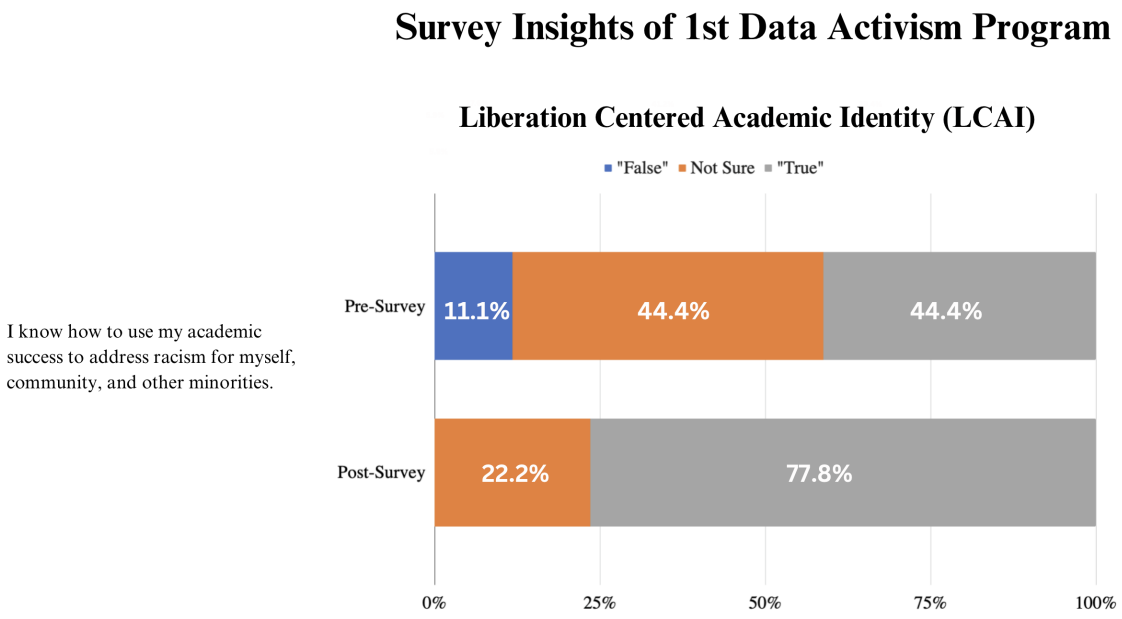


Figure 4-7: Survey Insights of 1st Data Activism Program: Liberation Centered Academic Identity

An additional survey question focused on assessing the students' beliefs regarding their educational utility, which is another aspect of LCAI. The results highlighted

the positive impact of the data activism class on the students' ability to utilize their academic achievements to benefit their community. Students were asked to rate their agreement with the statement "I know how to use my academic success to address racism for myself, community, and other minorities" on a scale of one (strongly disagree) to seven (strongly agree), as illustrated in Figure 4-7.

It is remarkable to observe an increase of 33.4% in the proportion of students who agree with the statement. Prior to the class, only four students expressed agreement, whereas after the class, the number of students in agreement rose to seven. In the post-survey, merely two out of nine students (22%) were unsure, and no one disagreed with the statement. These findings indicate that the curriculum might have effectively aided some students in understanding how they can utilize their academic success to support their community, a crucial skill for African Americans aspiring to become data activists. The results not only demonstrate an enhancement in some students' confidence in their coding abilities but also a positive shift in their perception of how academic success can be a catalyst in addressing racism. Although there is still room for improvement, these encouraging results imply that the curriculum has the potential to empower African American high school students, enabling them to become data activists who utilize their academic achievements to support other African Americans.

Collective Obligation

In this section, I will present the results from two of the six questions related to collective obligation. Collective obligation refers to the belief that individuals have a responsibility to their group and are motivated to take collective action. The results aim to demonstrate students' motivation and knowledge in engaging in collective action. Overall, the findings show no significant changes in student's confidence in working on a team and a slight increase in their strong agreement that people of color should help one another to decrease racism.

One of the questions assessed students' confidence in working on a team by asking them to rate their agreement with the statement "I know how to work on a team" on a

scale of one (strongly disagree) to seven (strongly agree) (Figure 4-4). The results from the post-survey indicated no significant changes, with the same number of students strongly agreeing (55.6%), one fewer student agreeing (22.2%), and one additional student neither agreeing nor disagreeing with the statement (11.1%). Overall, these results suggest that the first data activism curriculum could have benefited from incorporating more group activities to provide students with more opportunities to practice working collaboratively.

Another survey question investigated students' attitudes towards reducing racism by assessing their agreement with the statement "I believe that it is essential that people of color help one another in order to decrease racism" on a scale of one (strongly disagree) to seven (strongly agree), as depicted in Figure 4-4. Upon completion of the class, a majority of students (55.6% based on the post-survey) continued to strongly agree that it is crucial for people of color to support one another in diminishing racism. Moreover, there was an increase of two students (a 22.3% increase) who strongly agreed with this statement after participating in the program. These findings underscore the positive influence of the program on students' recognition of the importance of collective support among people of color in addressing and combating racism. This suggests that the program may have effectively shaped students' attitudes towards collective action.

Overall, the survey results indicate slight improvements in students' sense of collective obligation. Specifically, there were no significant changes in their confidence in working as a team. However, there was a strengthened belief among students in the significance of people of color supporting one another to combat racism. These findings highlight the positive impact of the data activism curriculum on students' collective obligation.

Activism Skills

While there are several skills that are essential to becoming an effective activist, this survey focused on assessing students' ability to use data science to mitigate systemic oppression. Some of these skills include analytic skills, strategic thinking

skills, and creativity skills. Out of the six questions asked, I will present two that were related to activism skills.

As an example, one of the questions in the survey asked students to rate their agreement with the statement, "I want to expand my computer programming knowledge" on a scale from one (strongly disagree) to seven (strongly agree) (Figure 4-4). This question aimed to gauge the extent to which students were interested in using coding in the future. It is understandable that two less students strongly agreed that they were interested in learning computer programming than at the end, as they were able to make more informed decisions about whether they wanted to continue pursuing programming by taking the data activism course. However, it is encouraging that even after learning advanced coding skills at the college level, the majority of students (eight) still expressed a desire to learn more about coding (88.9%), and no students stated that they did not want to learn more about computer programming. Specifically, after taking the class, six students strongly agreed (66.7%) that they wanted to learn computer programming, one person agreed (11.1%), one agreed (11.1%), and one neither agreed nor disagreed (11.1%) with the statement.

In addition, I requested students to indicate the extent to which they agree with the following statement: "I know how to utilize data science to help combat racism". Participants rated their responses on a scale from one (strongly disagree) to seven (strongly agree), and the findings are presented in Figure 4-4. Prior to the class, only one student (11.1%) possessed an understanding of using data science to combat racism. However, after completing the class, twelve students (77.7%) affirmed their ability to employ data science in mitigating racism to some extent. These results demonstrate the effectiveness of the class in teaching the majority of students how to combat racism using data science.

Overall, the data indicates a notable rise in the number of students equipped with the knowledge to apply data science in addressing systemic oppression. This outcome underscores the potential of incorporating liberatory computing tools into data science curricula to foster a greater understanding among students regarding the use of data science in mitigating systemic oppression. To further enhance student

preparation in combating systemic racism, it is recommended to develop additional project-based assignments that allow students to delve into topics that hold personal significance to them.

4.5 Discussion

Based on my data analysis, I have identified a need to incorporate more targeted lessons and activities on liberation tools that are not the main focus of the students' final projects, such as sound racial identity and collective obligation. This will help ensure an increase in the utilization of these tools among the students. One approach could be to integrate these tools into the final project itself, allowing students to explore and apply them in a practical and meaningful way. By incorporating these aspects into the curriculum, I aim to foster a deeper understanding and engagement with sound racial identity and collective obligation, promoting a more comprehensive and impactful data activism experience for the students.

For instance, the questions that showed the greatest difference in results were related to the purpose of the final project, which centered around using data science to mitigate racism. On the other hand, questions focusing on students' sound racial identity and the emotions they feel about their race did not exhibit significant changes. This could be attributed to the lack of a final project that was specifically designed to enhance positive emotions towards one's racial identity. However, there were multiple activities in which we discussed the hope that stems from being African American, such as the "African American Achievements" activity and the "Intersectionality Data Drawings Activity".

While there were no significant changes in the pre- and post-surveys regarding students' critical consciousness about African American history, the final projects provided explicit evidence of students' ability to independently conduct intersectional data analysis projects. Moreover, there was an increase in the number of students who agreed that they understand how to address racism through their academic success, with four additional students expressing this view. Additionally, seven more

students agreed that they understand how to use data science to combat racism. These findings suggest that my pedagogy and emphasis on the final project may be effective in motivating students to become data activists. To further explore the statistical significance of students' awareness of using data science to mitigate racism and their understanding of leveraging academic success for community impact, I designed the second data activism program for Boston African American high school students. In this second program, I observed significant increases in the number of students who recognize the potential of data science in addressing racism and who comprehend how their academic success can be utilized to benefit their community.

5

Data Activism Curriculum Design with Boston African American Students

Chapter five provides an overview of the second data activism curriculum. The second curriculum builds off the first by incorporating lessons that teach students how to collaborate with community organizations. The inclusion of the Critical Participatory Action Research Framework (CPAR) provides a framework for students to incorporate their community knowledge and lived experience into a data science curriculum. This is the first high school curriculum of my knowledge that ensures African American students not only use their advanced data science skills to understand vast amounts of quantitative data but also use the CPAR framework to analyze qualitative data and understand different perspectives by incorporating surveys and interviews from community members.

Students start by being introduced to the idea of AI bias as a call to action for the importance of knowing data science. Then, they begin to engage with the idea that the purpose of their research is to support community organizations. Therefore, all activities after Week 2 are geared towards preparing students to work with their specific community organization. For example, people in the Charles River Watershed Association (CRWA) group completed an intersectional data analysis activity and group discussion about environmental justice before working with CRWA. Students worked on their final projects for four weeks with their community organizers, created data activism projects for the real world, and presented their work visually in a way that is useful for community organizers and the broader public. Lastly, students presented their work to community organizations, community members, parents, families, and friends during two research symposiums at Harvard and MIT.

Now, we will discuss the additional activities that have been incorporated into the second data activism curriculum to equip students with the necessary skills for collaborating with community organizations. The detailed descriptions of each activity were contributed by Sophia Brady with the assistance of Olivia Dias. Moreover, I have formulated a chart that outlines the corresponding weeks during which these activities were conducted, along with the time required to complete the 50-hour worth of activities. For a full list of curriculum topics and learning objectives, see Tables 5.1, 5.2, 5.3, and 5.4.

5.0.1 Introduction to Critical Participatory Action Research

This activity explained Critical Participatory Action Research (CPAR). The students went through each word of CPAR- critical, participatory, action, and research- and recorded their initial interpretation of what the word means and how each word of CPAR interplays with each other. After the students discussed their preliminary ideas of CPAR, they watched a video that showcased a prime example of how high school students used CPAR to make their school more inclusive. The purpose of this assignment was to help the students co-construct an informal definition of CPAR. Additionally, students created a preliminary outline of the process their group might

follow during their CPAR work.

5.0.2 Daisy Model

This activity focused on the students' understanding of the data collection process for storage and analysis. The students participated in a unique exercise where they created a dataset by writing information about themselves, which was then represented as a Daisy Model. The Daisy Model, originally derived from the Coordinated Management of Meaning (CMM) communication theory, served as a tool to capture the various personal contexts that individuals bring into a conversation. Each petal of the Daisy Model represented a different aspect of the students' identity. In this activity, the Daisy Model was utilized to depict the diverse personal contexts that students perceive as integral to their identities. Following the creation of their Daisy Models, the students shared their drawings with their peers, explaining the significance of each petal. The purpose of this assignment was to facilitate the students' development of critical data analysis skills by employing a tangible representation of data.

5.0.3 Data in Google Sheets

This activity focused on students creating a group dataset based on the data from their Daisy Model's. To transform the data from the Daisy Models into a format suitable for storage in a dataset, the students divided into groups and utilized two processes: data standardization and data cleaning. During this phase, the groups devised unique column names to facilitate the consolidation of their data into a unified dataset. Once the students created their datasets, they uploaded them to a Google spreadsheet. The objective of this assignment was to assist the students in acquiring skills related to data cleaning, data labeling, and the utilization of basic tools in Google Sheets.

5.0.4 Breaking Down Stereotypes of Researchers

The purpose of this assignment was to assist students in challenging stereotypes associated with research and expertise, and to cultivate an understanding that diverse forms of knowledge existed within their CPAR group. Additionally, students were intended to recognize the significance of community knowledge and research in effecting policy change and fostering empowerment. Initially, students sketched their preconceived notions of a researcher's appearance. Subsequently, students participated in an activity aimed at visually illustrating the extensive array of community knowledge, experiential knowledge, and academic knowledge available to them.

5.0.5 Introduction to Intersectional Data Analysis

The purpose of this assignment was to conduct an intersectional data analysis on a social justice topic related to the community organization they were working with. For instance, students analyzed issues such as food insecurity, environmental injustice, and housing injustice in the Greater Boston area. First, students participated in a one-hour discussion about the systemic issue. Then, they utilized Deepnote to create intersectional data visualizations regarding their group's topic. All of the data science activities were done on Deepnote. It's important to note that since we had less time in the second data activism program, we were not able to teach as much of the functions in the Pandas library as was done in the first program. As a result, we created a "Pandas Dictionary" that contained predefined functions in a .py file that allowed students to do data analysis without having to worry about the complex syntax. Students still had to understand what was happening in the functions, but the predefined functions that contained the Pandas functions made the process easier for the students to debug since we had less time with them.

5.0.6 Research Methods Round Robin

Students gained exposure to diverse research methods, such as interviews and developed an understanding of their respective advantages and disadvantages. Initially,

they engaged in a survey exercise aimed at comprehending the distinct challenges present in specific schools. Following this, students participated in an arts-based activity that prompted them to visually capture a problem within their school that they wished to address. They could either take a photograph or create a drawing to depict the issue they aimed to rectify.

5.0.7 Developing Research Questions

During this lesson, students learned how to generate research questions that aligned with a specific research goal of making their school more justice-oriented. First, students learned the difference between equality, equity, and justice in order to better tailor their research questions towards justice and reviewed the core commitments of CPAR. Then, students learned about critical research questions by going through a "critical research question checklist" that sought to ensure that questions were focused on challenging oppression, clear about the population of interest and the type of data that would be collected, feasible, relevant, and open-ended. Afterwards, students watched a video about the school-to-prison pipeline and brainstormed potential research questions with the goal of solving injustices at their own schools.

5.0.8 Research Protocols

In this lesson, students learned how to create protocols based on the research method they chose. First, students watched a video that covered the key points when crafting a research protocol, regardless of the method. They learned the importance of consent and confidentiality, building rapport with research participants, asking descriptive and meaning-making questions, and balancing the breadth and depth of questions. Also, students learned about methods for qualitative data analysis, including thematic coding. Using what they had learned, students created a data analytic plan for their chosen research method.

5.0.9 Community Organization Background Research

In groups, students learned about the purpose of their community organization. First, students read about the organizations they would work with. They gained insight into the missions and project interests of their respective organizations. Then, they created three questions to ask the organization's representatives.

5.0.10 Relationship Building

Students participated in an icebreaker activity to get to know the community organizations. In their respective groups, each person wrote down a question that they would like others in the group to answer. Then, the students and community organization representatives took turns answering each other's questions in a circle. By the end of this activity, stronger connections were formed between the students and the community organizers with whom they were working.

5.0.11 Research Question

Students and community organizations brainstormed research questions together. Students were reminded of the critical research question checklist, and were encouraged to generate a question that fulfills the interests and needs of their organization. The research questions all challenged different forms of oppression.

5.0.12 Finding Open Data

The purpose of this assignment was for students to search for datasets online and request data that could be utilized to address their research questions. For instance, the group of students that focused on challenging food insecurity sought data that described the demographics of the food insecure population because their research question was about racial disparities in food accessibility.

5.0.13 Intersectional Data Visualizations for Final Projects

The purpose of this assignment was for students to use Python and Pandas to collect, manipulate, and analyze data on oppressed individuals or groups. Students were encouraged to analyze intersectionality. For instance, the group that focused on environmental justice analyzed how the intersection of race and class impacted environmental outcomes. With this in mind, the students used the data that was requested or found online to produce relevant data visualizations that helped answer their research questions. Students utilized Canva to enhance the accessibility of their visualizations.

5.0.14 Background Research

In their respective groups, the students conducted background research on the topic that their research question sought to understand. The background research was gathered via online and academic sources. The purpose of conducting background research was to guide data analysis, support the findings presented by the students' data visualizations, assist in creating survey questions, and ultimately help the students better understand and explain the social justice topic that they were addressing.

5.0.15 Create Surveys

The goal of this assignment was for the students to create survey questions that collected both qualitative and quantitative data from people in the Greater Boston area. First, the students were encouraged to review the special considerations for creating a survey to better understand how to ask clear, concise, unbiased, and non-leading questions. Then, the students reviewed their research question(s) and were encouraged to identify thematic categories. Within each category, the students developed specific survey questions. In small groups, the students piloted their survey questions, reading them aloud, to identify any necessary changes. The survey questions were also shared with the community organization to ensure they met their

project objectives. Revisions were made accordingly.

5.0.16 Send Surveys

T The goal of this assignment was to send the surveys to individuals residing in the Greater Boston area. First, the students identified who they would send their surveys to. For instance, the group focused on food insecurity considered sending their surveys to local food pantries in the Greater Boston area. Then, the students considered how and when the surveys would be distributed. With this in mind, the students contacted their identified distribution partners and made a plan for survey distribution.

5.0.17 Analyze Surveys

The objective of that assignment was to conduct a qualitative analysis of the survey's free-response questions and a quantitative analysis of the quantitative data. Firstly, the students identified various themes that emerged in the free-response questions. Then, using Miro, an online, collaborative whiteboard tool, the students created cluster maps for each survey question. Survey results were grouped into different clusters based on the themes that emerged in the responses. Subsequently, the students produced data visualizations given the quantitative data that they collected in the survey to identify patterns and form conclusions about survey responses.

5.0.18 Data Drawings

This activity utilized the results of the students' data analysis to inform art projects, including tote bags, stickers, t-shirts, zines, or other creative mediums, that raised awareness about the issues addressed in the data analysis. Students first brainstormed and selected an artistic project for this purpose, then identified the materials they needed to complete their project. Students were encouraged to create projects that informed others about their social justice topic and encouraged action

in addressing oppression. By the end of this activity, students knew how art could be used to represent social justice issues.

5.0.19 ArcGIS StoryMap

The objective of that activity was for students to utilize ArcGIS to develop interactive maps and slides for the final presentation of their data analysis. Firstly, using ArcGIS, the students created interactive maps that highlighted a geographical component of their social justice issue. For instance, the group focused on food insecurity overlapped a redlining map with a map of food insecurity to highlight how historical practices impacted food accessibility. Then, using the background research that students had previously conducted, they wrote an introduction, stated their project objective, and delivered a brief history of their topic. Students highlighted their analysis of the open data and survey results in the methodology and results sections. Finally, the students formatted their ArcGIS StoryMap and found relevant images to make their presentation visually appealing and accessible.

5.0.20 Data Activism Research Symposium

The aim of the symposium was to present the students' research. The research symposium was organized so that attendees could move freely between presentations to learn more about the students' research. Each research group was divided into two in order to present the group's findings to as many people as possible. By the end of the symposium, students should have felt more comfortable with public speaking and presenting research findings in a way that was understandable to a non-technical audience.

Week	Lesson Topic	Learning Objectives
1	Intro to Data Activism | 1 hour	Learn how AI algorithms can fail to recognize darker - skinned women, or misidentify them as males or animals. Learn the importance of analyzing data to develop AI that benefits society without causing harm to individuals.
1	Intersectionality | 1 hour	Introduce to the concept of intersectionality and learn about its significance. The aim is to provide them with a new framework that will allow for better self-examination and understanding of their place in society.
2	CPAR | 40 minutes	Gain an understanding of the process they might follow during their CPAR work.
2	Daisy Model | 40 minutes	Critically analyze data about themselves by listing different aspects of their identity
2	Data in Google Sheets | 45 minutes	Clean and label data related to a small group's identity to prepare it for analysis. Utilize basic Google Sheets to create a data set that captures different aspects of their group's identity for the purpose of conducting data analysis.
2	Intro to Python Part 1 | 45 minutes	Students will learn the basics of Python
2	Intro to Python Part 2 | 45 minutes	Students will learn the basics of Python and will be introduced to Pandas

Table 5.1: Learning Objectives for Data Activism Program with Community Organizations, Weeks 1-2

Week	Lesson Topic	Learning Objectives
3	Visualizing Data | 90 minutes	Learn how to make data visualizations using Python and Pandas.
3	Data Drawings | 45 minutes	Learn how data drawings can be more effective than traditional data visualizations in communicating systemic problems to a non-technical audience.
2	Breaking Down Stereotypes of Researchers | 25 minutes	Challenge stereotypes about research and expertise by breaking them down Acknowledge the existence of diverse forms of knowledge within a group, and the importance of community knowledge and research in effecting policy change and building power.
4 & 5	Intersectional Data Analysis | 9 hours	Conduct an intersectional data analysis on a social justice topic related to the community organization they will be working with. For instance, they may analyze issues like food insecurity, environmental injustice, or the impacts of redlining.
5	Research Methods Round Robin | 1 hour	Experience different research methods Understand the pros and cons of different research methods
6	Developing Research Questions | 90 minutes	Generate research questions that align with a specific research goal of making their school more justice oriented
6	Research Protocols | 45 minutes	Learn how to create protocols based on the research method they choose.
6	Community Org. Research | 20 minutes	Learn about the purpose of their community organization

Table 5.2: Learning Objectives for Data Activism Program with Community Organizations, Weeks 3-6

Week	Lesson Topic	Learning Objectives
6	Relationship Building | 40 minutes	Participate in an icebreaker activity to get to know the community organizations
6	Research Question | 2 hours	Students and community organizations are brainstorming research questions together
7	Open Data | 3-9 hours	Search for datasets online and request data that can be utilized to address their research questions
7-10	Intersectional Data Visualizations | 20 hours	Use Python and Pandas to collect, manipulate, and analyze data on oppressed individuals or groups Use Canva or other graphic design tools to enhance the accessibility of visualizations
7-10	Background Research | 15 hours	Conduct thorough background research on the topic
7-8	Create Surveys | 90 minutes	Create survey questions that collect both qualitative and quantitative data from people in the Greater Boston area
7-8	Send Surveys | 90 minutes	Send the surveys to individuals residing in the Greater Boston area
7-8	Analyze Surveys | 90 minutes	Conduct a qualitative analysis of the free-response questions and a quantitative analysis of the quantitative data
9-10	Data Drawings | 45 minutes	Utilize the data to inform their art projects, which can include tote bags, stickers, t-shirts, zines, or other creative mediums, that raise awareness about these issues
9-10	ArcGIS StoryMap | 45 minutes	Utilize ArcGIS to develop interactive maps and slides for the final presentation

Table 5.3: Learning Objectives for Data Activism Program with Community Organizations, Weeks 6-10

Week	Lesson Topic	Learning Objectives
10	Data Activism Research Symposium | 4 hours	Present their research to over 70 people at MIT and Harvard

Table 5.4: Learning Objectives for Data Activism Program with Community Organizations, Weeks 10

6

Data Activism Program with Boston African American Students

This chapter provides a comprehensive examination of the second data activism program's study design, participant demographics, class setting, data collection, and analysis, specifically highlighting the results obtained from the pre- and post-surveys. By focusing on African American high school students from the Greater Boston area who actively collaborated with community organizers and incorporated data activism into their personal lives, the analysis offers valuable insights into the impact of the second data activism program. It contributes to our understanding of how such initiatives can empower and equip African American students to effect positive change through data activism.

6.1 Study Design

This section provides an overview of the study design of the second data activism program, which aimed to explore the collaboration between students and community organizers and the integration of data activism into their personal lives. The research study focused on the following main research question:

> How do the data activism curricula prepare students to engage in data activism? Additionally, what is the impact of implementing different data activism curricula on students' proficiency in each liberatory computing pillar?

The research question for the second data activism program is:

> How does equipping students with intersectional data analysis skills and integrating CPAR skills enable students' proficiency in each liberatory computing pillar?

To address the research questions, a mixed-methods approach was utilized. Qualitative analysis centered on the examination of the students' CPAR projects, as well as interviews conducted with both the students and community organizers. In parallel, pre- and post-surveys were administered to collect quantitative data. Overall, this mixed-methods study provided a comprehensive understanding of how the students actively collaborated with community organizers on their data activism projects. The study involved the instruction of 24 African American high school students from the Greater Boston area who actively participated in the 10-week data activism program. It is worth noting that this study underwent a thorough ethical review process and received approval from the MIT Committee on the Use of Human Experimental Subjects (COUHES). Furthermore, all students and staff involved in this project completed research ethics training, ensuring the ethical conduct of the study.

6.2 Participants and Class Setting

From February to April 2023, a total of 24 African American high school students from the Greater Boston area participated in the ten-week data activism program. The recruitment process involved word-of-mouth, email invitations, and a Zoom informational session to reach potential participants. In order to accommodate more students, classes were conducted via Zoom throughout the week. The students were divided into four groups for the Zoom class, with each group receiving one hour and 30 minutes of instruction during the week. Following the virtual class sessions during the week, all 24 students had the opportunity to come to the MIT Media Lab for a five-hour Saturday class, which included a designated one-hour lunch break. This in-person session provided a valuable hands-on experience and enhanced the collaborative learning environment of the data activism program.

Furthermore, the program fostered meaningful partnerships with three community organizations: Habitat for Humanity Greater Boston, Food Link, and the Charles River Watershed Association. The active involvement of these organizations proved instrumental in supporting the students' projects and creating a real-world context for their data activism initiatives. Their collaboration added practical significance to the program, allowing the students to apply their skills and knowledge to address pressing social issues in collaboration with established community organizations.

Throughout the duration of the 10-week program, a significant amount of my time, approximately 60-70 hours per week, was dedicated to administrative tasks and supporting students with their final projects. Administrative duties included managing the curriculum schedule, facilitating gift card distribution, communicating schedule revisions, coordinating meetings with the COUHES offices, organizing the research symposium, presenting students' projects to key stakeholders, and revising consent forms, among other responsibilities. The remaining time was devoted to conducting review sessions, managing schedules, communicating schedule revisions, sending reminders, providing assistance with final projects, updating community organizations on student progress, and conducting regular class sessions. To ensure personalized as-

sistance and support, Zoom and email were utilized to address the needs of students who missed class or required additional guidance with their advanced college-level final projects. These measures were implemented to ensure that every student had access to the necessary resources and support throughout the program.

6.3 Data Collection and Analysis

Building upon the success of the first program, this phase involved comprehensive data collection methods, including conducting 16 hours of interviews with students and community organizers. Additionally, three collaborative final projects were analyzed, and pre- and post-surveys were administered to gather quantitative data. The interviews underwent transcription using Otter.ai's transcription feature, followed by a meticulous review to ensure accuracy. The assistance of undergraduate researchers was enlisted for the transcription processes. Subsequently, I conducted a thorough thematic analysis of the qualitative data. To ensure data confidentiality, all interview data were securely stored on a cloud accessible only to the principal investigator, senior researchers, undergraduate researchers, and myself. Furthermore, the students completed a series of 28 survey questions designed to measure their proficiency with various liberation tools, readiness to become data activists, and future plans for utilizing different aspects of data activism. The Appendix contains the pre- and post-survey questions administered to the high school students, as well as the post-interview questions conducted with both the high school students and the community organizers.

In this research project, ethical considerations were of utmost importance, and written consent and assent were obtained from all participating students, parents, and community organizers prior to data collection. Notably, this study marked a distinctive endeavor for MIT, as it was the first time the institution engaged in a project that provided substantial compensation to minors and community organizers for their valuable contributions over an extended duration. Extensive meetings with MIT officials were held to ensure proper handling of such situations. After thor-

ough discussions, new rules and precedents were established to ensure appropriate compensation for community organizers and students.

To maintain continuous compliance with ethical standards, I maintained daily communication for five months with the COUHES offices, MIT offices, parents, students, and community organizers. Every aspect of the project was approved by MIT officials, including the MIT VP of Finance, COUHES office, and Media Lab Admin, ensuring participants were adequately compensated and kept informed about any updates to the study. The long-term nature of this research study, involving minors collaborating with their community and receiving compensation at MIT, required regular adjustments throughout the program to ensure all stakeholders were aware of the unique aspects of the program. It is my aspiration that this project can serve as a precedent for students and community organizers to engage in justice-oriented collaboration within institutional research settings, providing support and opportunities for meaningful participation.

6.4 Pre- and Post- Survey Results

A survey consisting of 28 questions was administered to all 24 students, and 17 students responded to the survey. In this section, we will delve into eleven survey questions that correspond to various liberation pillars, elucidating how these questions aided in a more accurate assessment of the students' readiness to become data activists. To determine the statistical significance of the discrepancy between certain pre- and post-survey results, we utilized the Mann-Whitney U test and the Kruskal-Wallis test. The results of the statistical analysis on the majority of the survey questions are depicted in Figure 6-1.

Sound Racial Identity

This section focused on evaluating students' relationship with their racial identity, which is crucial to becoming effective data activists. A strong racial identity includes feeling positive about one's racial group, acknowledging negative societal attitudes

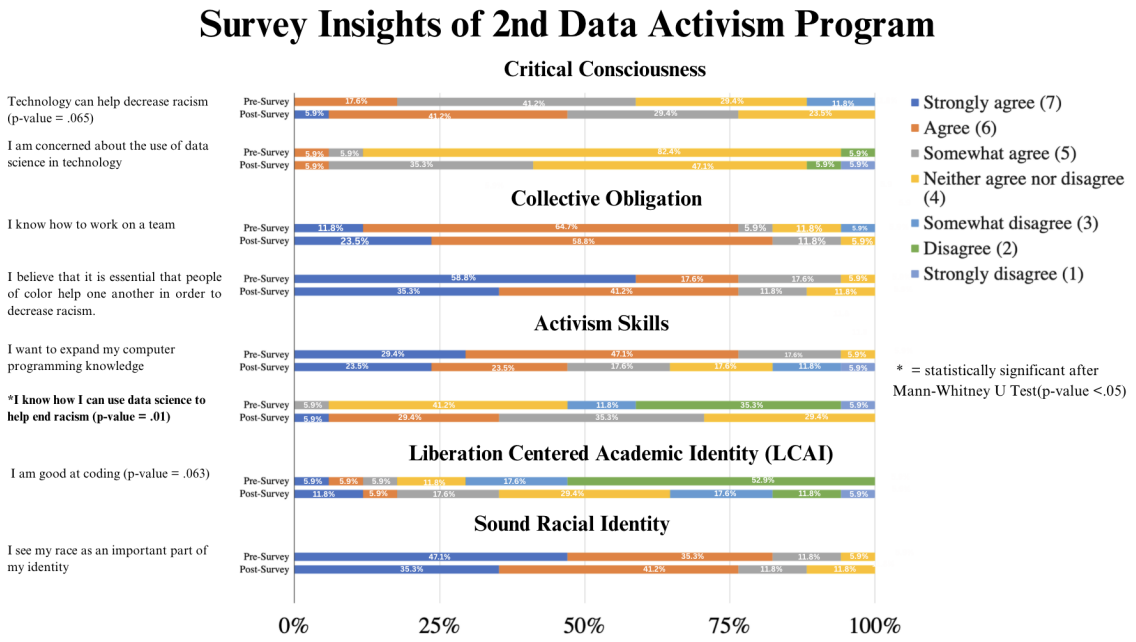


Figure 6-1: Survey Insights of 2nd Data Activism Program

towards that group, and recognizing the significance of one's race in shaping their identity. In this section, I will present the results from three survey questions related to racial identity.

One of the questions analyzed in this section asked students to rate their agreement with the statement "I see my race as an important part of my identity" on a scale of one (strongly disagree) to seven (strongly agree) (Figure 6-1). There were not any significant changes in the pre- and post- survey results. The results from the post-survey showed that one less person agreed with the statement on some level. The pre-survey had 94.2% of students agree on some level that they see their race as an important part of their identity. The post-survey had 88.3% of students agree with this statement on some level. Based on the results of the Mann-Whitney U test with the provided data, we cannot conclude that there is a significant difference in whether they see their race as an important part of their identity between the pre-survey and post-survey (p-value = 0.50 and statistic = 163.0). This decrease in the number of students that see their race as an important part of their identity may have been due to the fact that we did not do the "African American Achievements activity, which

was done during the first data activism program. While the curriculum may have influenced students' views on their racial identity, it is unclear why there were no significant changes observed in the role of race in students' personal identities.

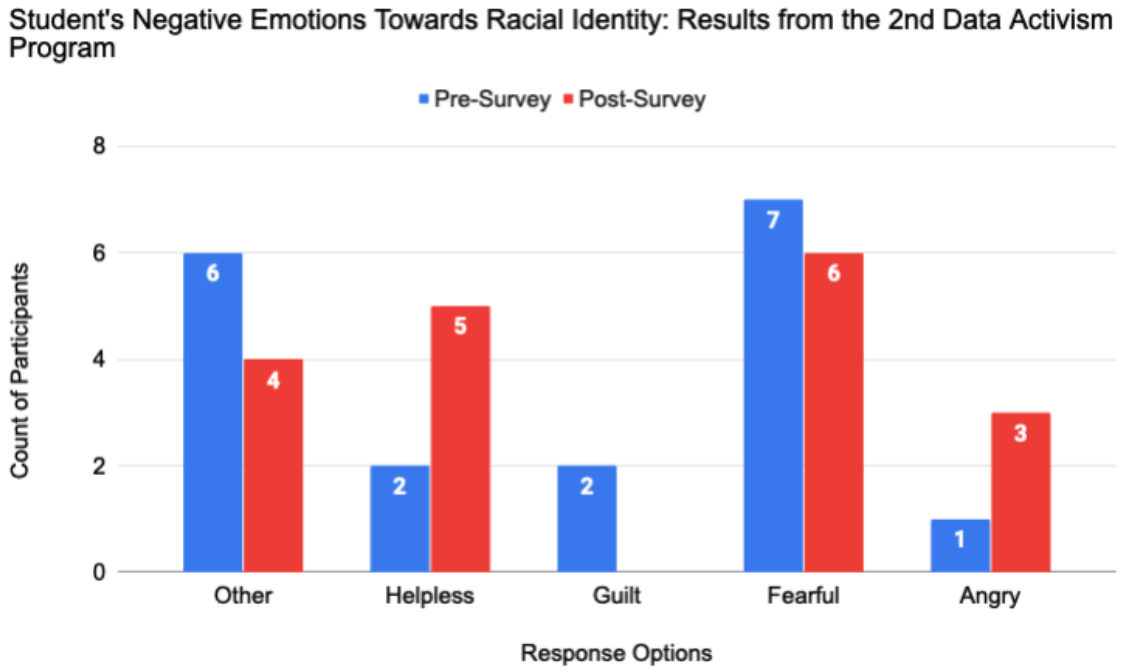


Figure 6-2: Student's Negative Emotions Towards Racial Identity: Results from the 2nd Data Activism Program

One question I asked in the survey was about the negative emotions students sometimes feel about being a member of their race, including feeling Helpless, Guilt, Fearful, Angry, or Other. Students could choose more than one negative emotion (Figure 6-2). In the pre-survey, as indicated by the "Other" option, three students reported not feeling any negative emotions, one felt annoyed, one felt underrepresented, and one felt unbothered. In the post-survey, four students reported not feeling any negative emotions, while one felt annoyed. Compared to the pre-survey, in the post-survey, three more students felt helpless about their race, and two fewer students felt guilty. However, there were six more instances of negative emotions expressed overall after students finished the data activism program. However, the analysis conducted using the Kruskal-Wallis test with the available data does not provide sufficient evidence to conclude a significant difference in students' negative emotions towards

their racial identity between the pre-survey and post-survey. It's difficult to draw any clear trends from the results of this question as there are only slight variations in the number of students reporting different negative emotions in the pre- and post-survey. Further analysis with a larger sample size may be needed to draw any significant conclusions about changes in students' negative emotions related to their race.

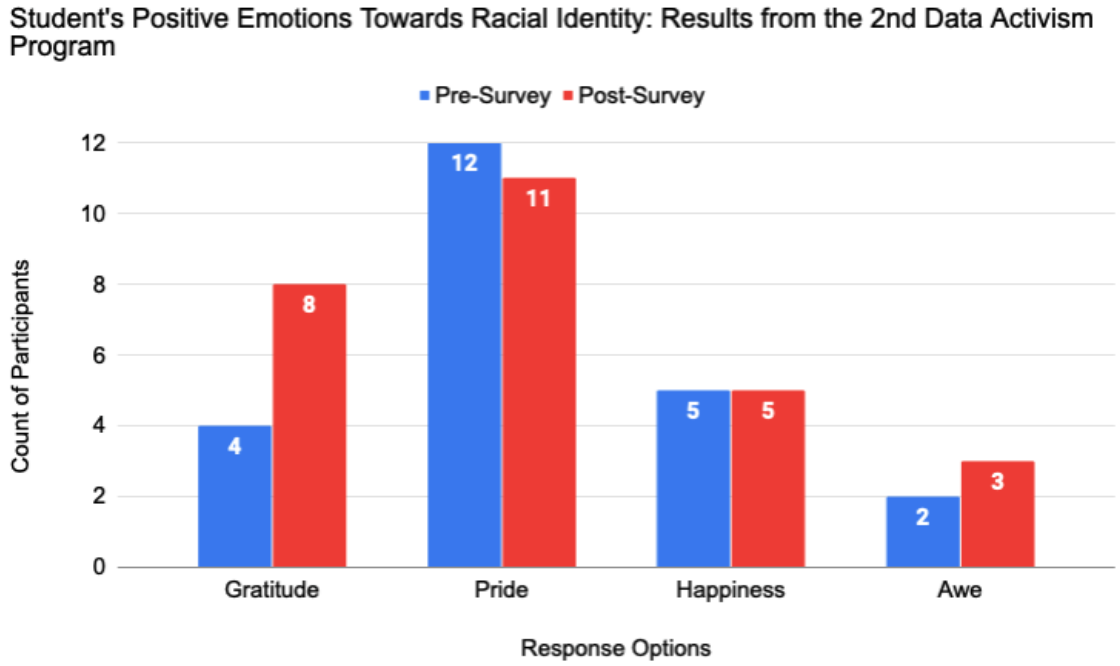


Figure 6-3: Student's Positive Emotions Towards Racial Identity: Results from the 2nd Data Activism Program

One question in the survey aimed to assess students' positive emotions regarding their racial identity, encompassing feelings of gratitude, pride, happiness, and awe (Figure 6-3). The pre-survey recorded 23 instances of positive emotions, while the post-survey showed an increase to 27. Specifically, four more students reported feeling gratitude, one fewer student expressed a sense of pride, and one additional student experienced a sense of awe. However, the analysis conducted using the Kruskal-Wallis test with the available data does not provide sufficient evidence to conclude a significant difference in students' positive emotions towards their racial identity between the pre-survey and post-survey. Nevertheless, the overall rise in positive emotions observed after students completed the post-survey suggests that the curriculum may

have had a positive impact on their attitudes towards their racial identity. It is important to note that during interviews, nine out of 17 students indicated that the program enhanced their pride and confidence in their racial identity. Therefore, it is crucial to consider these results holistically, combining both the quantitative and qualitative data. However, to draw definitive conclusions, further analysis and a larger sample size are necessary.

The decline in the number of students perceiving their race as an important part of their identity, as well as the lack of significant changes in their positive feelings about their race in the survey, may be attributed to the absence of the "African American Achievements" activity conducted during the first data activism program. This activity aimed to enrich students' racial identity by allowing them to explore the remarkable accomplishments of African Americans. Its purpose was to inspire students and cultivate their understanding of how they can achieve greatness by learning from the achievements of notable African American figures. Moving forward, I will make an effort to incorporate the "African American Achievements" activity into future projects to ensure its positive impact on students' racial identity. Although the survey results did not show significant changes, it is worth noting that Chapter 7 provides insights from interviews, which indicate that the curriculum did increase the majority of students' confidence in their racial identity. Thus, it is important to consider both the quantitative and qualitative data to gain a comprehensive understanding of the curriculum's influence.

Critical Consciousness

This section presents the results of a survey question related to critical consciousness that was asked to students. In order to effectively fight for racial justice, African Americans need to possess critical consciousness and a clear understanding of the persistence of racism [15]. The three main components of critical consciousness are critical reflection, sense of agency (self-efficacy), and critical action. The survey question I will discuss in this section assessed students' critical reflection, while their sense of agency and critical action were evaluated through interviews and projects.

One survey question asked students to rate their level of agreement with the statement "I am concerned about the use of data science in technology" on a scale of one (strongly disagree) to seven (strongly agree), as shown in Figure 6-1. The results indicate that after the class, five more students somewhat agreed with the statement(29.4% increase), six less people neither agreed nor disagreed, and one person strongly disagreed. Based on the analysis conducted using the Mann-Whitney U test with the available data, it cannot be concluded that there is a significant difference in students' concern about the use of data science in technology between the pre-survey and post-survey (p-value = .239 and statistic = 115.0). This increase in the number of students concerned about data bias may have been influenced by the lessons on AI bias. This demonstrates that a few students increased their critical reflection. These findings suggest that some students have developed a better understanding of how data science can harm others, indicating that the study may have been effective in teaching students about the potential of AI bias.

Another question posed to the students was their level of agreement with the statement "Technology can help decrease racism" measured on a scale of one to seven, as depicted in Figure 6-1. Prior to the class, 58.8% of students agreed with the statement to some extent. However, after the class, 76.5% of students indicated their belief that technology can contribute to reducing racism. The analysis conducted using the Mann-Whitney U test with the available data does not provide sufficient evidence to conclude a significant difference in students' belief regarding the potential of technology to combat racism between the pre-survey and post-survey (p-value = .065 and statistic = 93). It is possible that there was a slight increase in the percentage of students who agree with this statement to some degree due to the second program's emphasis on students using data science to address systemic oppression.

The fact that the question regarding students' belief in technology's potential to decrease racism is approaching statistical significance is encouraging because the main purpose of the class was to show students how they can use data science to combat systemic racism. It is promising to see that the results are close to being statistically significant, considering the students' engagement in their final project

with community organizations, which they dedicated four weeks to. This underscores the importance of having students undertake final projects as it allows them to fully grasp the lesson objective and apply their knowledge in a practical setting.

Furthermore, it is worth noting that the first program placed significant emphasis on addressing AI bias through the COMPAS Recidivism activity. Therefore, it is plausible that fewer students from the first program agreed with the statement. These findings highlight the impact of activities specifically addressing AI bias on shaping students' views of technology and its potential to combat racism. To gain deeper insights into students' beliefs and better understand the reasons behind their perspectives, conducting interviews would be a valuable next step. Interviews can provide a more comprehensive understanding of students' experiences and explain the factors influencing their views on technology's capacity to address racism.

Liberation Centered Academic Identity (LCAI)

To assess different components of having an LCAI, I asked students five questions. In this section, I will present the results from two of these questions. LCAI addresses two specific dimensions of African Americans' academic identity: "a) their academic self-concept, which refers to their beliefs about their ability to achieve and is cultivated through an Embedded Achievement Philosophy, and b) their educational utility beliefs, which refers to their understanding about the purpose of achievement and is cultivated through an Achievement for Freedom Philosophy" [15]. Overall, there was a slight increase in the number of students who felt that they were proficient in coding and a significant increase in the number of students who recognized the potential of using their academic skills to address racism.

One of the survey questions assessed students' self-concept in relation to coding, and the results indicate that a few more students felt confident in their coding skills after taking the class. I asked them to rate their agreement with the statement "I am good at coding" on a scale of one (strongly disagree) to seven (strongly agree), as shown in Figure 6-1. Before the class, only 17.7% of students agreed to some degree that they were good at coding. After the class, 35.3% of students agreed

to some degree that they are good at coding (a 17.6% increase) post-surveys. It is important to note that the results for this question are close to statistically significant. This suggests that the curriculum might be effective in decreasing the number of students who felt they were not good at coding. Analyzing the available data using the Mann-Whitney U test, it cannot be concluded that there is a significant difference in students' belief in their coding skills between the pre-survey and post-survey (p-value = .0635 and statistic = 91.5). This suggests that the curriculum may have been effective in reducing the number of students who felt they were not skilled at coding. This might be attributed to their lack of prior experience with coding. Overall, these findings indicate there might be a positive trend in students' confidence in coding abilities, although further investigation and analysis would be beneficial to gain deeper insights into the impact of the curriculum on their perceptions and experiences.

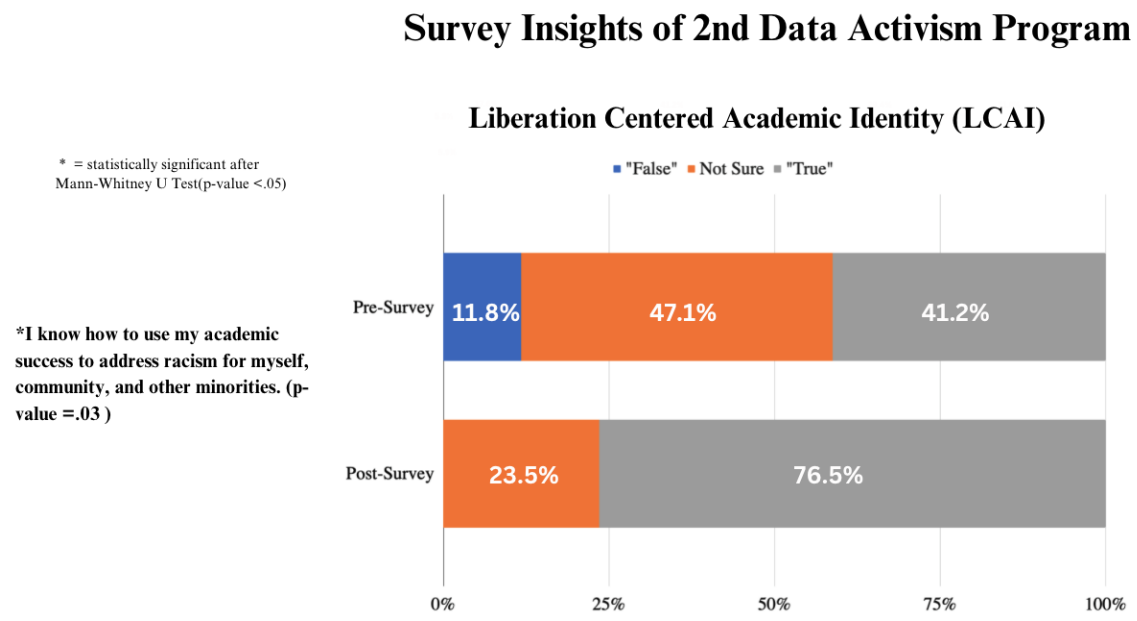


Figure 6-4: Survey Insights of 2nd Data Activism Program: Liberation Centered Academic Identity

Another question in the survey assessed the students' educational utility beliefs, a key aspect of LCAI. One of the survey items asked students to rate their agreement with the statement,"I know how to use my academic success to address racism for myself, community, and other minorities". Figure 6-4 provides an overview of the

results. The findings indicate that the data activism class had a positive impact on students' ability to utilize their academic success to support their community, as the results reached statistical significance.

In the pre-survey, 41.2% of students knew how to use their academic success to address racism for themselves, community, and other minorities. In the post-survey, 76.5% of students agreed with this statement, indicating a 35.3% increase. Based on the analysis conducted using the Mann-Whitney U test with the available data, it can be concluded that there is a significant difference in students' understanding of the role of using their academic success to address racism between the pre-survey and post-survey (p-value = .0305 and statistic = 89.5). These results indicate that the study successfully aided students in comprehending how to leverage their academic achievements to support their community, which is an essential skill for African Americans aspiring to become data activists.

Overall, it is truly gratifying to witness a notable rise in the number of students who possess the knowledge and skills to utilize their academic success as a means to combat racism, both within their own lives and for the betterment of their communities and other marginalized groups. This positive outcome may be attributed to the students' engagement in projects that held personal significance and directly contributed to their communities. By providing students with the opportunity to apply their acquired knowledge in practical ways, such as supporting organizations like Food Link, the Charles River Watershed Association, and Habitat for Humanity Greater Boston through their final projects, their understanding and application of the concepts were further reinforced. This hands-on experience allowed them to see the tangible impact of their efforts and solidify their commitment to addressing social injustice.

Collective Obligation

In this section, I will present the results from two of the six questions related to collective obligation. Collective obligation begins with group identity and often transitions into a set of beliefs about the group that lead to collective action[15]. The goal

is to assess students' motivation to act towards the needs of a shared collective and their ability to engage in action together. Overall, the results suggest that the data activism curriculum might have successfully promoted a sense of collective obligation. Specifically, the results indicate an improvement in the confidence of a few students in working on a team. Furthermore, there has been a slight decrease in the number of students who agree that it is essential for people of color to support one another in order to decrease racism.

One question assessed students' confidence in working on a team, asking them to rate their agreement with the statement "I know how to work on a team" on a scale of one (strongly disagree) to seven (strongly agree) (Figure 6-1). Prior to taking the class, 82.4% of students believed that they knew how to work on a team to some extent. After completing the class, 94% of the class agreed to some degree that they know how to work on a team, reflecting an 11.6% increase. However, based on the analysis conducted using the Mann-Whitney U test with the available data, it cannot be concluded that there is a significant difference in students' ability to work as a team between the pre-survey and post-survey (p-value = .362 and statistic = 121.0). Overall, the results suggest that the data activism curriculum successfully enhanced the confidence in working on a team for a few students.

A question aimed at evaluating students' attitudes towards decreasing racism assessed their agreement with the statement "I believe that it is essential that people of color help one another in order to decrease racism" on a scale of one (strongly disagree) to seven (strongly agree), as depicted in Figure 6-1. Prior to the class, 94% of students agreed with this statement to some extent. After the class, this percentage decreased to 88.3%, representing a 5.7% decrease. Based on the analysis conducted using the Mann-Whitney U test with the available data, it cannot be concluded that there is a significant difference in students' belief in collective action amongst people of color to reduce racism against African Americans between the pre-survey and post-survey (p-value = .908 and statistic = 141.0).

Overall, the majority of students still maintain the belief that it is crucial for people of color to support one another in order to combat racism. Also, there is

a slight increase in the number of students that know how to work on a team after taking this class. These findings suggest that the data activism curriculum might have had a positive impact on enhancing students' confidence in collaborative teamwork and fostering more favorable attitudes towards collective action. However, further research is necessary to better understand the extent of this influence and explore potential improvements for future iterations of the program.

Activism Skills

While there are several skills that are essential to becoming an effective activist, this survey focused on assessing students' ability to use data science to mitigate systemic oppression. Some of these skills include analytic skills, strategic thinking skills, and creativity skills. Out of the six questions asked, I will present two that were related to activism skills.

I included a question in the survey that asked students to rate their agreement with the statement, "I want to expand my computer programming knowledge" on a scale from one (strongly disagree) to seven (strongly agree). This question aimed to gauge the extent to which students wanted to use coding in the future and possibly as an activism skill. Before the program started, 94.1% of students(16 students) agreed that they wanted to learn about computer programming to some extent. After the program, 64.6%(11 students) of students agreed that they wanted to learn about computer programming to some degree(a 29.5% decrease). It is understandable that more students were interested in learning computer programming at the beginning of the program than at the end, as they were able to make more informed decisions about whether they wanted to continue to pursue programming by taking the data activism course. Based on the analysis conducted using the Mann-Whitney U test with the available data, it cannot be concluded that there is a significant difference in student's desire to expand their computer programming knowledge between the pre-survey and post-survey (p-value = .108 and statistic = 190). However, it is encouraging that even after learning advanced coding skills at the college level, the majority of students still expressed a desire to learn more about coding(64.6% of students or 11 students).

In the survey, the students were asked to rate their agreement with the statement "I know how to utilize data science to help combat racism." The question was assessed on a scale ranging from one (strongly disagree) to seven (strongly agree), and the outcomes are illustrated in Figure 6-1. Prior to the class, only 5.9% of students agreed, to any extent, that they possessed knowledge on utilizing data science to address racism. However, after the class, an impressive 70.6% of students reported being aware of how to apply data science to mitigate systemic racism. This demonstrates a significant improvement in students' comprehension of utilizing data science to combat racism, representing a substantial 64.7% increase. Furthermore, it is worth noting that no students disagreed with the statement after the class. By conducting an analysis employing the Mann-Whitney U test with the available data, it can be concluded that there exists a significant difference in students' understanding of using data science to help end racism between the pre-survey and post-survey (p-value = .01 and statistic = 72.0). These findings affirm that the class effectively taught a larger number of students how to employ data science in combating racism.

Overall, the data illustrates a remarkable rise in the number of students equipped with the knowledge to apply data science in addressing systemic oppression. The results from the second program highlights the significance of incorporating projects that enable students to learn about data science and racism while fostering their activism skills. It is crucial for students to develop confidence in their activism skills to become data activists. The students not only understand the importance of utilizing data science to reduce racism but also have the ability to create data activism projects that make a tangible impact in collaboration with community organizers.

7

Insights from Qualitative Data: Boston African American Students' Experiences in the Data Activism Program

In this section, I will discuss the different community research projects that the students completed with community organizers, my analysis of their projects, and community organizer and student interviews.

7.1 Critical Participatory Action Research Final Project Analysis

During the last four weeks of the program, 24 high school students collaborated with community organizers on a final project centered around data activism. The goal was to support the community organizations and the people they serve. Although one student left during the seventh week and did not present, the other 23 students presented their final projects using an ArcGIS StoryMap, which offers interactive engagement with maps and data visualizations through an online website. One of the high school students had to present their work via zoom. All the data visualizations were created using Python and Pandas on Deepnote, an interactive data analysis notebook. Subsequently, students utilized Canva, a graphic design website, to enhance the accessibility of the visualizations, and ArcGIS to create interactive maps.

The students were divided into three groups, each focused on one of the three community organizations. The Habitat for Humanity group comprised seven high school students, two community organizers from Habitat for Humanity, and two undergraduate researchers who supported the high school students. This group's objective was to gather information that Habitat for Humanity Greater Boston could use to prioritize building in areas with better access to resources or to develop better support strategies for families with limited access to essential resources.

The Food Link group consisted of eight students, one community organizer from Food Link, and two undergraduate researchers. Food Link is an organization that delivers fresh, healthy food from restaurants and grocery stores to food pantries, with the aim of ensuring that everyone has access to nutritious food. Their project aimed to understand which towns in the Greater Boston area struggled the most with food insecurity, as well as the demographics of those areas and the reasons why certain groups were impacted more than others, whether for historical, social, or political reasons.

The Charles River Watershed Association (CRWA) group was made up of eight

high school students, one community organizer from CRWA, and two undergraduate students. CRWA's mission is to protect, restore, and enhance the Charles River and its watershed using science, advocacy, and the law. The objective of this group was to analyze the impact of flooding in areas predominantly inhabited by marginalized groups in collaboration with the Charles River Watershed Association (CRWA).

The 22 students presented their work to an audience of more than 70 individuals at the Data Activism Research Symposium. Additionally, some students showcased their research at Harvard during the CPAR Research Symposium for K-12 students. In addition to presenting their research findings, they shared their data drawings, which were created based on the data analysis they conducted. These data drawings provided a visual representation of their research, allowing the audience to better understand their findings and conclusions. I will describe each of the group's final projects below. Here are the links to the different groups and their respective websites:

- Habitat for Humanity ArcGIS StoryMap link: `https://storymaps.arcgis.com/stories/d92a0a238b3d4173ae6136178e9561d1`
- Charles River Watershed Association ArcGIS StoryMap link: `https://arcg.is/1ji10z1`
- Food Link ArcGIS StoryMap link: `https://arcg.is/11jXT80`

7.1.1 Habitat for Humanity

Introduction

The students in this group have conducted research on the neighborhoods of Roxbury and South Boston. Roxbury is known for its rich history and culture, including its ties to African American history and culture, as well as its family-owned businesses and traditions such as parades. However, the group's research focuses on the hardships faced by Roxbury, specifically the relationship between housing and other community assets. One student shares a personal story about growing up in Roxbury and the societal problems that result from underfunded schools and lack of government assistance. Despite these challenges, she still calls Roxbury home and wants

to support her community. The group also researched South Boston, a neighborhood with high income and housing demand due to its proximity to the city center. The project objective is to explore the relationship between resource availability and income inequality in Boston neighborhoods, with a focus on Roxbury and South Boston.

Why this topic?

The students chose to research the racial homeownership gap in Boston, where only 30% of African American residents and 17% of Latinx residents own their homes compared to 44% of Caucasian residents. They aimed to explain the historical reasons behind this gap, as well as its impact on other community assets. The group presented a graph illustrating the significant disparity in median net worth between Caucasian and African American families in Boston. According to the graph, the median net worth for White families in Boston is $247,500, while for Black families, it is $8. The median net worth and limited homeownership among African Americans are crucial factors that influence their livelihood. Consequently, the absence of reliable transportation in Roxbury becomes a significant concern in this context. Roxbury already faces challenges such as food insecurity, safety concerns, and income disparities, and the lack of accessible transportation only exacerbates these issues. The students believe that everyone deserves equal access to safe, affordable, and decent housing, and they hope to raise awareness of this issue through their research.

Objective

The students' research findings will be utilized by Habitat for Humanity Greater Boston to determine areas for prioritized building projects and to develop better support strategies for families with limited access to essential resources. Their research focused on the availability of critical community assets, such as hospitals, green spaces, schools, transportation, and food. The students hope that their work will contribute to improving the quality of life for residents in Boston by advocating for more equitable access to these resources.

History of Redlining

The students conducted research on Boston's history of high levels of segregation,

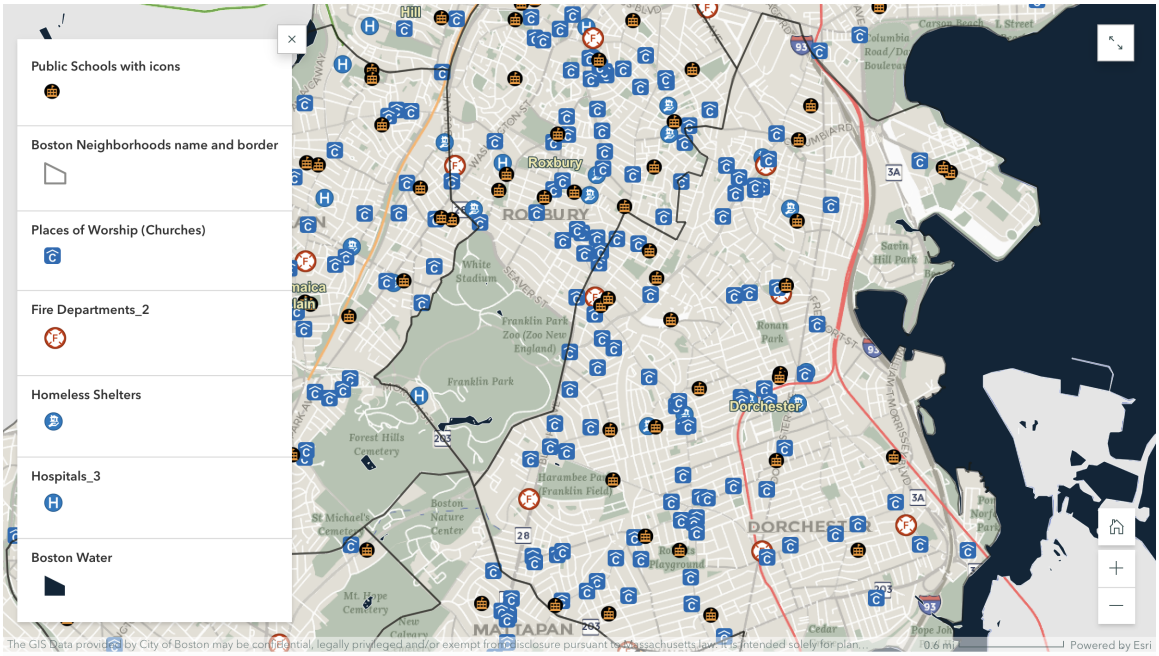
particularly on its effects on Roxbury due to redlining. They explained that redlining is a form of racial discrimination where mortgage lenders or insurance companies deny services to certain populations. Although it is now illegal, redlining has had lasting repercussions on cities in America, including Boston. Redlining in Roxbury led to decreased investments, declining property prices, and high levels of violence, which continue to impact the neighborhood today. The students hope to raise awareness of the lasting effects of redlining and advocate for greater equity in access to resources in historically marginalized communities.

Data Analysis Methods

The students utilized data analysis to explore the racial gaps present in South Boston and Roxbury. They used Python and Pandas, popular data analysis tools, to clean and analyze the data. The first step was cleaning the data and better understanding it through visual explorations. After, they demonstrated some examples of how they cleaned the data using various functions, such as the *replace* function to change zip codes to neighborhood names, making it easier to follow along. The *contains* function was used to only keep the desired neighborhoods, South Boston and Roxbury, and they deleted all the rows that did not feature these neighborhood names. The group by function was used to calculate the total acres in the desired neighborhoods. Overall, the students' data analysis helped them better understand the racial disparities in South Boston and Roxbury and provided a foundation for developing support strategies for families with limited access to essential resources.

Data Analysis Using Open Data

The students used data analysis to explore racial gaps in South Boston and Roxbury. They obtained data from the city of Boston's open-access data repository on various community assets such as schools, transportation, green spaces, and food. Python, Pandas, and ArcGIS were used to clean and visualize the data. They created over 30 data visualizations to support Habitat for Humanity Greater Boston. The presentation encompassed a range of informative visualizations. Among them were representations showcasing the number of trees and open spaces in various neighborhoods. Additionally, data regarding the total acres and percentage of open space



Habitat for Humanity Greater Boston Map for Story Map at the end

Figure 7-1: This ArcGIS Map explores community assets in Boston neighborhoods. Habitat for Humanity Greater Boston will use this information to prioritize building and support strategies.

in South Boston and Roxbury were visually displayed. In terms of demographics, significant information about Roxbury was highlighted. Furthermore, maps were presented, illustrating the locations of important facilities and services in Boston, including public schools, fire departments, police stations, hospitals, places of worship, and homeless shelters. These visualizations collectively provided valuable insights into the community resources within Boston (see Figure 7-1).

Data Analysis from Surveys

The students conducted a survey to gather Boston resident's thoughts on access to community assets. They received 66 responses within a week and a half and analyzed 26 questions for preliminary qualitative analysis. Some respondents indicated limited access to resources that hindered education, while others reported difficulty accessing healthcare resources. Some respondents also expressed a desire for safer and more easily accessible parks. Due to the limited timeframe, the students presented their preliminary analysis.

Conclusion and Next Steps

The students emphasized the importance of people creating programs and opportunities that can contribute to the improvement of Roxbury for future generations. They acknowledged that such endeavors would require both time and patience to yield meaningful results. They also shared that community organizations will be using their data activism project to support African American, Latinx, and low-income communities in owning a home, prioritizing personalized education, improving access to mental health resources, and providing more open spaces. The students emphasized the need for patience and time to see the desired changes in Roxbury, including more peaceful strolls down Marcella Park. In addition, they invited the audience to explore their final map, which combines all their intersectional data analysis in one place, allowing viewers to explore the availability of various community resources such as greenspace, education, healthcare, and food access across Boston's different neighborhoods. The students hope that this map provides a comprehensive view of the contrast in community resources' availability, leading to informed decision-making to address these disparities.

Data Drawing

The students engaged in a project called "Data Drawing" where they collected photos and created 50 copies of the same zine to highlight the assets of their neighborhoods in Boston, such as Roxbury, Dorchester and Mattapan (see Figure 7-2 and 7-3). The zine includes images that showcase the community assets in these neighborhoods. Through this project, the students aimed to challenge negative stereotypes and promote a more positive image of their communities.

7.1.2 Food Link

Introduction

The students' data activism project with Food Link aimed to address food insecurity in the Greater Boston area. They presented their project with an introduction highlighting the story of Zuri Dixon, a mother of four special needs teenagers who struggles with food insecurity despite her husband's full-time employment. The urgency of addressing food insecurity was emphasized, and the students aimed to

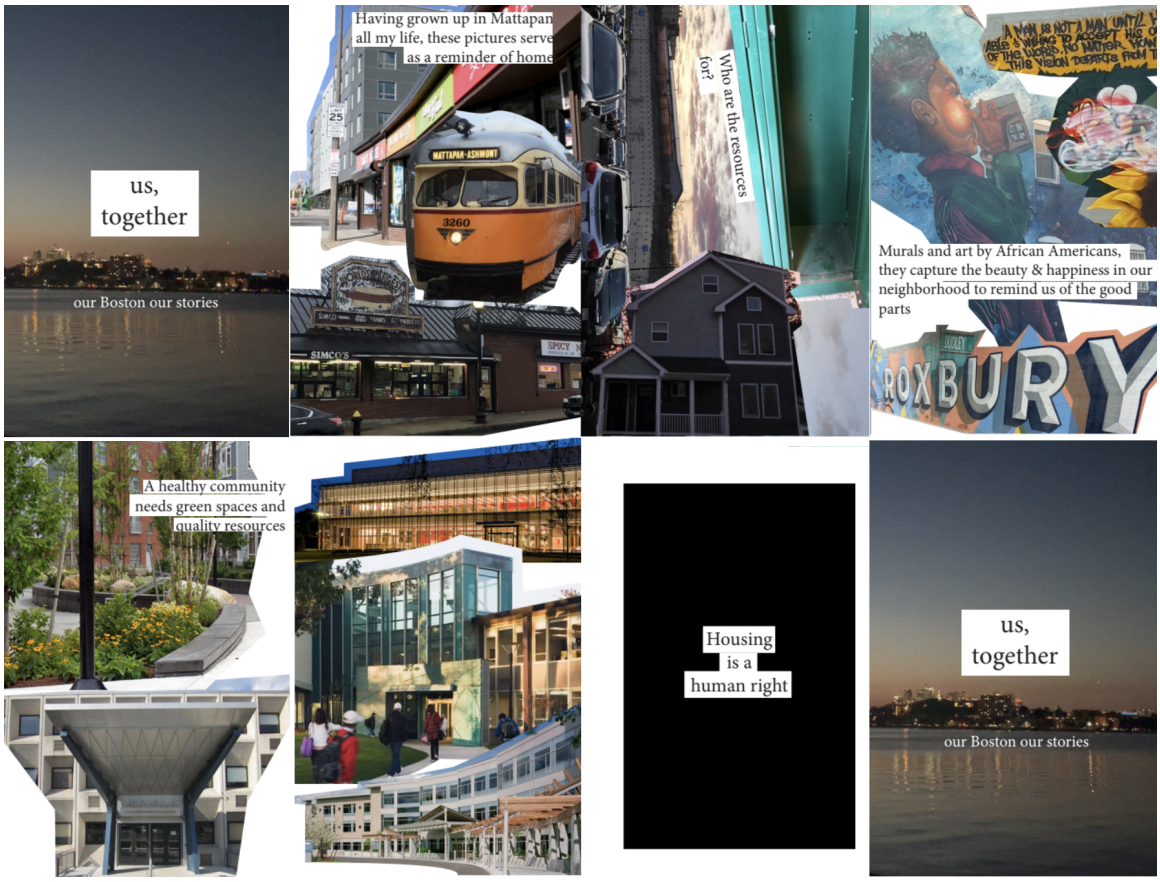


Figure 7-2: Images from Habitat for Humanity Group Zine

understand which towns in the Greater Boston area were most affected by food insecurity. They also wanted to explore the demographics of those areas and the reasons for the impact, whether historical, social, or political. Their results showed that the 10 Greater Boston towns with the highest food insecurity rates and food budget shortfalls had a significantly higher Latinx and African American population and low-income population.

Why this topic?

The students presented their data activism project on food insecurity, which they worked on with Food Link. They began by highlighting the severity of the issue in Boston, affecting around 497,000 people and 1 in 11 children. The team expressed their gratitude for working with Food Link, an organization committed to providing fresh, healthy food to those in need. Additionally, some team members have experienced the challenges of food insecurity, making this topic very personal and important

to them. The team hopes their work will bring attention to the issue and encourage others to take action to address food insecurity in Greater Boston.

Objective

The students' project objective was to analyze food inequality data in Boston to identify the most impacted demographic groups and the reasons behind it. They also aimed to gain a deeper understanding of food insecurity and the factors that contribute to individuals and communities facing challenges in accessing sufficient and nutritious food in Boston. By doing so, they hope to raise awareness about the issue of food insecurity and inspire others to take action to address it in their community.

History of Food Insecurity

In their data activism project on food insecurity in Boston, the students explored the history of redlining and its lasting impacts on immigrant, African American, and Latinx communities in Boston. Redlining, which originated in the 1930s through the Home Ownership Loan Corporation, marked "dangerous" neighborhoods in red on maps, with most of those areas being minority/low-income neighborhoods. The group realized that this practice has a strong link to food insecurity in Boston, as it led to a lack of investments in minority communities and made it difficult to set up shops and grocery stores in these neighborhoods (see Figure7-4). In addition, redlined areas often lack infrastructure for healthy food options, like public transportation and walkable streets, and have limited employment opportunities, making it difficult for residents to access healthy food.

Methods

The students used Python and Pandas to analyze data about food insecurity. They used various functions to identify patterns and relationships in the data, visualize it, and identify areas that are succeeding or struggling in reducing food insecurity. Next, the group calculated the correlation between different variables, such as median household income and food insecurity rate, using the correlation function. Then, the students created a dataset from a list of values and indices and selected specific columns to view. Also, they created a bar chart from the resulting dataset to visualize

the data. Overall, these methods were essential in analyzing the data about food insecurity and gaining insights into the problem.

Data Analysis Using Open Data

The students conducted an analysis of food insecurity in the Greater Boston Area using Python and Pandas. In their results section, they focused on the food budget shortfall, which represents the additional amount of money a food-insecure person would spend to meet their needs. They used bar graphs to identify the 10 Greater Boston towns with the largest food budget shortfalls and found that the towns with the largest shortfalls have a greater percentage of Latinx and African American populations and smaller median family incomes compared to towns with the smallest food budget shortfalls (see Figure 7-5). The students also observed that almost all the redlined districts now reside in towns with high rates of food insecurity. Based on their analysis, the students recommended that Food Link prioritize communities with high levels of food insecurity, food budget shortfalls, and low median household incomes, so they can better assist the communities in greatest need of food.

Data Analysis from Surveys

The survey analysis is based on data collected from 27 respondents, mainly from regulars at the Cambridge Community Center Food Pantry and the Salvation Army Food Pantry in Cambridge. Most survey participants reported feeling well-supported by their local food pantries, but the students wanted to understand why people opt to go to food pantries instead of grocery stores. Survey results showed that grocery stores are just as accessible as food pantries to the community in terms of distance and transportation. However, most survey respondents live in a household where they support two or more people and spend much less on groceries per week than the average of $300 per month for a 4-member household. Free food at pantries or via SNAP is a daily necessity for most food-insecure families. The qualitative analysis revealed that some people receive additional help from family/friends, work/volunteering, or do not receive any additional help. Respondents wanted more food that matches their food and dietary needs when they go to food pantries, and some suggested that food pantries could provide better quality and quantity of food if they received more

support.

Conclusion and Next Steps

The students concluded that food insecurity is a critical issue in the Greater Boston area and emphasized the need for community awareness and support. They conducted research to gain a better understanding of the people and their access to food beyond Food Link. The next steps for their community organization involve developing strategies to improve food access for those in need, taking into account the information they gathered from their research.

Data Drawing As part of their "Data Drawing" project, the students utilized block printing techniques to create unique designs for over 40 tote bags and t-shirts (see Figure 7-6). Each item featured graphics and phrases aimed at highlighting the urgent need to close the meal gap in Boston and spreading awareness about mitigating food insecurity. The students' creative use of block printing helped to visually convey their message and encouraged others to join their cause. Overall, their efforts were a meaningful contribution towards raising awareness and promoting positive change in their community.

7.1.3 Charles River Watershed Association

Introduction

The students' presentation began by taking the audience back to the 2018 "bomb cyclone" that caused widespread flooding and chaos on the streets of Boston, as reported by *Business Insider*. They then highlighted how flooding is also a major problem in the Dorchester neighborhood. With climate change continuing to escalate, the students warned that flooding could become an even bigger issue in the future. They noted that flooding disproportionately impacts low-income communities and areas with higher populations of African American and Latinx residents, such as Dorchester. To better understand the impact of inland flooding on marginalized communities, the students partnered with the Charles River Watershed Association (CRWA), an organization dedicated to protecting and restoring the Charles River and its watershed through scientific research, advocacy, and legal action.

Why this topic?

The students explained their motivation for selecting the topic of flooding in the Boston area. Their primary goal was to raise awareness about the negative impacts of inland flooding, such as the spread of infectious diseases, unsafe food and drinking water, and loss of access to medical services. They were also passionate about this topic because they recognized that it will affect their own futures, communities, and the daily lives of their families and friends. By addressing this important issue, the students hoped to inspire others to take action towards mitigating the impacts of flooding on vulnerable communities in Boston.

Objective

The students shared their research objective of investigating whether there is a connection between redlining and the communities that are most impacted by inland flooding. They expressed hope that their data analysis would reveal what kind of aid these communities require, as well as provide solutions to mitigate the damage caused by historical injustices. By examining the intersection of historical discriminatory policies with present-day environmental issues, the students aimed to shed light on the ongoing impacts of systemic racism and social inequalities in Boston. Their research has the potential to inform policies and practices that promote equity and address the needs of marginalized communities in the face of climate change.

History of Redlining and Environmental Injustice in Boston

The students provided background information on the topic of their research. They explained that redlining, a discriminatory practice that limited access to financial resources in predominantly African American, Latinx, and low-income communities, perpetuated generational poverty. They also highlighted the connection between the lack of green space and the prevalence of heat zones in Dorchester, which is partially due to redlining. Furthermore, the students presented data showing that redlined communities are more likely to experience disproportionate rates of home damage due to flooding, with a total risk of $107 billion for homes at high risk of flooding. They specifically mentioned Dorchester as a redlined community with a large African American population that is at risk for flooding due to its proximity to

the Boston Harbor and the Neponset River. By providing this contextual information, the students aimed to illustrate the historical and ongoing impacts of systemic racism on vulnerable communities and emphasize the urgency of addressing environmental justice issues in Boston.

Methods

The students used various datasets, including those from Analyze Boston and the National Oceanic and Atmospheric Administration storm events database, as well as surveys from homeless shelters, hospitals, community centers, and care homes. They learned Python and Pandas to analyze the datasets and created over 20 different data visualizations. One of their methods involved creating a bar chart to compare hospital counts across neighborhoods. They also used the *statistic* function with the *groupby* option to calculate total acreage per neighborhood and identify areas with particularly large or small amounts of land.

Data Analysis Using Open Data

The students used open data to analyze potential stormwater flooding in different areas of Boston. They used data from the National Oceanic and Atmospheric Administration to estimate how much rain is likely to fall during a storm and factored in the higher sea level to determine the areas most at risk of flooding. The students created maps showing the areas that will be affected by floods in the 2030s-2050s and the 2070s or later, as well as a map showing the community assets, such as churches, homeless shelters, and hospitals, that would be affected by a flood (see Figure 7-7). Also, students also created bar charts showing the number of people per hospital and fire department in each neighborhood, providing a visualization of the impact of potential flooding on the community (see Figure 7-8).

Data Analysis from Surveys

The students conducted a survey analysis in the Greater Boston Area, receiving 67 survey responses within a week and a half. They found that the majority of survey responders were not aware of inland flooding, but had experienced or knew someone who had experienced basement flooding or household damage. The students were surprised by the high number of people with flooding experiences. They concluded

that their survey and work would be crucial in raising awareness and educating the public on the risk of inland flooding and how they could help their communities.

Conclusion and Next Steps The students' research focused on the connection between redlining and communities disproportionately impacted by inland flooding in Greater Boston. The students concluded that inland flooding in Greater Boston is a critical issue that could be addressed by the community and local government through the creation of more green spaces. They encouraged people to visit the Charles River Watershed Association website to increase awareness of environmental justice and created stickers to spread awareness (see Figure 7-9).

7.2 High School Student Post-Interviews

After the students finished presenting their projects, I conducted individual interviews with them in order to gather more information and insights to answer my research questions. These interviews lasted between 15 and 35 minutes, and allowed me to delve deeper into the topics discussed in their presentations and gain a better understanding of their thought processes and decision-making throughout the project. Currently, I have analyzed 17 interviews.

Question 1: What have you learned about inequality against African Americans in this project?

During the interviews, our focus was to understand the students' knowledge about inequality against African Americans. In response to our question, "What have you learned about inequality against African Americans in this project?" I received 17 responses that highlighted two significant themes related to African Americans. Firstly, all 17 respondents mentioned the inequality in access to resources, indicating that the students understand that African Americans face a disproportionate lack of access to resources compared to other groups. Secondly, AI bias affecting the recognition of African American women was the second theme, mentioned by three respondents. These findings reflect the students' awareness of a vast amount of challenges faced by African Americans.

17 students emphasized the first theme, highlighting that African American individuals, experience inequality in accessing resources such as food and housing due to discriminatory practices like redlining. Within this group, six students specifically mentioned the effects of redlining on African Americans, preventing them from accessing resources like home ownership and building generational wealth. One participant noted that redlining has prevented African Americans from building generational wealth for hundreds of years. Similarly, another participant stated that inequality can manifest in education and wealth, not just through overt racism. One student explained, "I learned that redlining negatively impacts Black people and how they're able to purchase homes from mortgage lenders."

The second theme points out the issue of AI bias and its impact on the recognition of African American women. The students noted that AI often fails to properly recognize African American women's features and often assumes they are men. One student explained,

> I discovered that much of today's technology is not geared towards African American women, as they often lack proper gender recognition and are assumed to be men. Even well-known Black women such as Michelle Obama, Serena Williams, or Oprah are not recognized by everyday AI technology.

This is supported by one participant, who mentions AI bias as a significant issue facing African Americans.

Overall, the students' responses highlight their knowledge of ongoing challenges and injustices faced by African Americans in accessing resources and facial recognition. They also demonstrate that the students have learned about the need for continued efforts to address these issues. Furthermore, they suggest that some students are learning about how AI has the potential to both perpetuate and address these inequalities, emphasizing the importance of ensuring that AI is developed and implemented in ways that promote justice.

Question 2: How has this project impacted your motivation to broaden your knowl-

edge of African American history and social justice? What aspect of African American history are you interested in?

According to the responses of the 17 students who answered this question, this class had a significant impact on their motivation to broaden their knowledge of African American history and social justice. Several themes emerged from their answers about the aspects of the class that motivated them to learn more about African American history. The most commonly reported motivation was the desire to address racial inequalities and promote social justice (15), followed by an interest in the lessons about AI bias (five) and learning about African Americans in STEM (two). It is worth noting that some of the responses touched on multiple themes.

The first theme that emerged was motivation to address racial inequalities and promote social justice. 15 students expressed this interest, with one student stating,

> I've always been interested in the beginning, particularly slavery, the Civil War, and related historical events. I believe my curiosity stems from the fact that we never discussed these topics in school.

Several students expressed that they were motivated to learn more about African American history in general, including topics such as redlining and the wealth gap, and environmental justice. They also reported feeling more motivated to address systemic racism and how it is implemented in different systems.

One common theme was the interest in addressing AI bias and learning about how data collection and AI algorithms can perpetuate discrimination against certain groups. Five students expressed this interest, with one student stating, "I had never even heard of that before. So that was definitely really interesting for me to learn about." Another related theme was being able to learn about African Americans in STEM, including in data science and medicine. Two students expressed this interest.

In addition, the project helped one student learn to collaborate and work as a team, recognizing the importance of working together to address complex issues such as AI bias and systemic racism. Another student felt more engaged and motivated in their learning, recognizing the potential real-world impact of their research. One

student expressed an interest in learning about other minoritized races they identify with. Furthermore, the responses highlight the diversity of interests and perspectives within the group of students, suggesting that the project was successful in encouraging students to pursue their individual passions and to find meaningful connections between their interests and the broader themes of African American history and social justice.

Question 3: How, if in any way, has this project influenced your outlook on your racial identity? and Do you feel more confident in your race?

Inquiring about the impact of a project on participants' racial identity, two questions were asked: "How, if in any way, has this project influenced your outlook on your racial identity?" and "Do you feel more confident in your race?" The majority of students reported an increase in their confidence in their race(9), while others had a heightened awareness of racial identity issues (5), and five did not experience a significant change in confidence in racial identity. It's worth noting that some respondents' answers overlapped across multiple themes. For those who reported that their confidence did not increase, they still acknowledged that their awareness of the challenges faced by people of their race had grown. Additionally, they expressed that they already held a strong sense of pride and confidence in their racial identity.

Nine participants expressed that the project increased their pride and confidence in their racial identity. One student stated how they appreciated their heritage and felt more positive about it by stating

> This class helped me recognize that despite the challenges African Americans have faced and overcome, they continue to grow and exceed expectations.

Three of these participants specifically noted that working with other African Americans helped them with their confidence. Additionally, one student acknowledged the importance of working with peers of the same race and said,

> Working alongside my Black peers in this class has given me a newfound sense of confidence. Knowing that we share similar goals and aspirations,

> and are experiencing similar struggles, has been incredibly empowering. Their support has strengthened my belief that there are like-minded individuals out there who also seek to make a difference.

Another student stated,

> While it's true that Black girls can do anything that a White guy can, I felt a stronger sense of affirmation while working with people who looked like me. Learning coding as a whole and going through the process has been an empowering experience.

They appreciated the support they received from peers who shared their goals and aspirations.

Five students reported no significant change in their confidence in racial identity. Out of the five people that stated that there was no significant change in confidence in racial identity, one of them stated that they had an increased desire to express their racial identity, and two of them stated that they had a greater understanding of how widespread these issues were in the African American community, with one stating

> It made me think about more than the things that can be inaccessible to me in the future. I may not be able to own a home just because of the color of my skin. I may not be able to get a job, I may not be able to do get into the STEM program or do something just because I am the way I am.

Furthermore, a student reported that although their confidence in their racial identity did not increase, they recognized the similarities between their own experiences and those who grew up in redlined areas. Another student who did not experience an increase in confidence stated that this class provided an alternative means of expressing their identity. One student in particular was empowered by this project to express themselves more freely, and to recognize the validity of their African American identity. The project helped the student understand the worth of their identity.

The student's response indicated that the project gave them the courage to pursue their ambitions and succeed in the face of adversity, defying negative statistics and naysayers.

Question 4: To what extent, if any, have you incorporated other interests, such as art into your project?

All 17 students had answered the question, "To what extent, if any, had you incorporated other interests, such as art into your project?". Every student had been able to incorporate a personal interest into their final project. The students had all been able to incorporate their diverse interests. The main themes that had emerged were the ability to incorporate their interests in art(10), history(three), and writing (three).

The use of art was an important theme that had emerged from the program. Participants had used art in various forms to communicate their message and convey their ideas. Three people had mentioned enjoying doing the Data Drawing activity about intersectionality where they had been able to create a drawing that represented different aspects of their identity. Two people had enjoyed photography. They had used photography to show the disparities in cleanliness in different areas of Boston, creating a Zine that had incorporated artistic elements and personal perspectives to inform the community about the issues they had uncovered. Two people had mentioned that they had enjoyed creating tote bags that had stamps that had helped people spread awareness about food insecurity. One student had stated,

> Something that I'm interested in is photography. I took different pictures in the zine that showed different areas on Boston. Like for example, one of the photos I showed was at school and how it was dirty, it was unclean, and just showed that there needs to be changes in Boston right now. I had ones of houses. I had ones of stores and dirty lockers in school. The pictures had been from Dedham and Hyde Park. I had been trying to use my photos to show the disparities in cleanliness in different community assets.

Writing had been another important theme that had been intertwined with the others. Participants had enjoyed the process of researching and writing about their findings, which had been essential to the completion of their final project. They had used writing to present the history of redlining in Boston, African American history, and personal stories that had contributed to the overall message of the project. The project had also incorporated a historical perspective, with participants discussing the history of redlining and African American history. Three people had stated that they had enjoyed how the project had incorporated history.

One student had stated that they had enjoyed working with others and collaborating as a team. This person had discussed the enjoyment of working with people to make a difference, which had been reflected in their use of surveys to gather information and gain feedback from the community. Also, one person had enjoyed being able to verify information with their own personal experiences. They had stated,

> Well, in this project, we had been focusing on just Roxbury and South Boston, so I had been able to share my own personal story, and also just reverified information where we had been wondering was transportation really an issue, and I can attest to that. I can tell you how many healthy food places there and honestly verify the information, because I am a resident.

This participant had used their own experiences to contribute to the historical narrative and inform the community about the impact of these historical events on their lives. Overall, the themes of the project had been interconnected and had worked together to create a comprehensive and informative message for the community. By working together, using surveys, art, writing, history, and personal stories, the participants had been able to communicate their message in a way that had been both engaging and informative, while also making a difference in their community.

Question 5: What was your experience with working with community partners like so far?

I asked the students, "What was your experience like working with community

partners so far?" After interviewing 17 students, it was evident that they had a positive overall experience. The majority of students noted that their positive experience was due to the expertise and knowledge that the community partners brought to the project. However, three students stated that they would have benefited from more time with community organizers, and one student stated that they wished they could work with more than one community organizer.

All 17 students expressed appreciation for the information and guidance provided by the community organizers. Specifically, students mentioned how the community partners were able to provide them with a different perspective and help clarify their ideas. Some students appreciated the interactive nature of the community partners, as it allowed them to work collaboratively. One student stated,

> It was honestly great. I already knew about Habitat for Humanity, but they really explained their goal and mission to me. Even from that, I think it made our project a lot easier because they helped us decide what to focus on. So I think they were really great support.

Although these students wanted more time with the community organizers, they still enjoyed working with them. This theme was noted by three students and is an important consideration. These students felt that more time would have allowed them to delve deeper into the organization's work and gain a better understanding of its mission and goals. One student stated,

> Even though they were not very present for a lot of the time, I feel like they gave good information. They were easygoing and I learned that they liked their job but also likes doing other things besides their job. I liked creating the research questions with them, and I also liked their feedback because I feel like it helped me and my team grow as people individually and together.

One student even wished they had the opportunity to work with more than one community organizer to gain diverse perspectives on the organization.

Overall, the positive experience that the students had with the community organizers reflects the importance of community partnerships in projects. It also highlights the valuable knowledge and expertise that community partners can contribute to student-led projects. While most students felt they had sufficient time with the community organizers, three students felt that additional time would have been beneficial, and one student wanted to work with more than one community organizer. These insights provide important considerations for future projects with community partners.

Question 6: How do you plan on incorporating data activism into your everyday life?

The responses to the question "How do you plan on incorporating data activism into your everyday life?" revealed that participants were interested in exploring potential actions for data activism. All 17 students expressed a desire to use data activism to spread awareness about specific issues in their everyday lives. While seven students expressed a broad interest in incorporating data activism by joining community organizations, doing research projects, volunteering for food pantries, taking social justice classes, and being mindful of what they have, the other 12 students had specific ideas on how to use data science and social justice in the future.

One student said,

> I'm interested in doing data activism for my school or church. I'm interested in finding the classes that people are more likely to not do as well. Also, I'm interested in connecting those people with tutors and specialists in their field to form study groups. Yeah, my mom was on the Church Committee and I still happen to overhear some things. Sometimes, they like to try and check in on people who haven't been present in the church as much as they have before. So I guess we could like keep a tally of who hasn't been in the community as much. And then try and send care packages.

Another student said,

> I would be aware of certain topics. So like, if I was really into searching into a specific topic in my city, I think I would definitely use data science to help me find specific details. And also, I would probably use it in projects as well, if I was to ever take, like a class or statistics class next year in the future, and it just helped me see things in a deeper view.

Additionally, one student mentioned,

> Honestly, since I'm really interested, I want to do a lot of research on my own time and honestly, just practicing my coding skills and figure out how to incorporate that in a social justice way, which like, I'm already trying to do, but as of right now, I believe just doing more research and what other problems need to be solved and practicing my coding so I could even teach others or how others could use it.

Question 7: How has your idea of data science and coding in general changed? Was coding "intimidating" and if so is it still "intimidating"?

This is a qualitative analysis of 17 students' responses to two themes related to their perception of data science and coding. In particular, the analysis focuses on how their perceptions have changed over time and whether they still find data science and coding intimidating. 17 students were asked about their idea of data science and coding, and their responses were categorized into two themes: feeling less intimidated after the class(16), and not finding it intimidating ever(1).

For the first theme, most of the students expressed feeling intimidated initially but less so after taking the class. They reported that they were not expecting everything, found it more difficult than they had anticipated, and had assumed that coding was just plugging in a bunch of numbers. One student stated,

> It can be stressful at times, especially during the Deepnote part, where you have to ensure that you are typing everything correctly, using certain data sets, and avoiding duplicate entries. Additionally, sending out surveys and cleaning them can add to the stress. However, it becomes less intimidating once you get the hang of it.

Once the students received more practice, they found it less intimidating than before. One student stated,

> I initially found it very intimidating because when you see all these cool things, you might think, "I won't be able to do that." But you're not expected to learn everything all at once. I was pleasantly surprised to find that I could do some really cool things that I did not even know were possible, and it quickly became less scary.

Some students also mentioned that the class helped them become more confident in looking at data, cleaning it, and finding trends. One student stated,

> When I first heard of data science, I was a little worried about it because I never heard of anything like that. I did not know how to properly clean data or even look at it when there's so much of it or even properly organize it. But now I feel confident at actually looking at data, cleaning it, and making the data more understandable.

Overall, the students in this theme expressed feeling less intimidated after the class than before.

In contrast, a student in the second theme reported not finding coding intimidating because they focused on understanding each line of code one step at a time, even though it was their first time coding. Another student mentioned that any subject can be intimidating if one lacks passion or remains fearful of it. In conclusion, the analysis shows that while most students initially felt intimidated by coding and data science, they felt less intimidated after taking the class. Some students also reported feeling more confident in their abilities to analyze and clean data. However, a few students did not find coding intimidating, indicating that individual perceptions of coding may vary.

Question 8: Do you see yourself using data science/ coding techniques in the future?

I asked students whether they saw themselves using data science or coding techniques in the future. It seems that all students are considering the possibility, but

there is a mix of those who may continue learning about it (eight) and those who are definitely interested (nine).

Of the nine students who expressed definite interest, some mentioned they want to take more coding classes to improve their skills. One student said, "I've always been interested in coding, and I'm not going to stop now. I'm going to keep looking for different programs and ways to improve." Three students expressed their desire to use data science for activism or in their future careers. For example, one student wants to incorporate coding into civil engineering to collect qualitative data from real people before building structures. Another student wants to use data science to help political figures in Boston hold fundraisers and connect with supporters in their jurisdiction. Another student said,

> Seeing what you do and all the other data scientists and undergraduate students kind of helped me more on my journey because I honestly do want to do data science and social justice together in the future.

The eight students who were uncertain expressed the possibility of using data science in their future careers as doctors, travel nurses, marine biologists, presidents, artists, or businesspeople. For example, one student said, "I'm not really sure how you would use coding as a doctor, but if there was an instance where I could use it, that would be really cool." Overall, the conversation demonstrates a positive attitude towards coding and data science skills, with participants recognizing the importance of these skills in their future personal and professional lives.

7.3 Community Organizer Post-Interviews

The community organization interview questions aimed to gather insights from four local organizations regarding their experience working with the students who participated in the data activism program. This section presents the results of these interviews and examines the feedback received from these community partners. The responses offer valuable insights into the impact of the data activism program on the

community and provide a unique perspective on the effectiveness of the curriculum in preparing students for authentic data activism. Through the analysis of these results, we can gain a better understanding of how the program has influenced the students' engagement with local organizations and how the program can be improved in the future to better serve the community.

Question 1: What surprised you about how class went?

After conducting a qualitative analysis of the question "What surprised you about how class went?" we identified a central theme: the exceptional professionalism displayed by the students throughout various aspects of the data activism project (seven). Within this theme, we identified several reasons why community organizers were particularly impressed with working with students, including their enjoyment of getting to know students (one), their surprise at how knowledgeable the students already were (three), their appreciation of the students' creativity (one), their admiration of the initiative and interest that students took in the learning process (one), and their delight in the symposium (one). These findings highlight the importance of creating engaging and interactive learning experiences that foster personal relationships, empower students, and encourage the development of practical skills and tools.

In particular, one reason why some of the community organizers were surprised by the student's professionalism was the students' surprising level of knowledge. Two community organizers stated that they were surprised by the students' professionalism because of the students' data skills, particularly their use of Python and map creation. One community organizer expressed surprise at the level of analysis that came out of the students' work and the final map creation. This community organizer said,

> I was impressed by the students' data skills, particularly their use of Python for data cleaning and analysis. Although I have never used Python before, I was able to see the screenshots of their work, and it was surprising to me how sophisticated their analysis was. I was also pleasantly surprised by the final map creation, which was easy to navigate and allowed for zooming in and out.

One other community organizer stated that they were surprised by the students StoryMaps that the students presented at the Data Activism Research Symposium. This theme highlights the importance of integrating practical skills and tools in the learning process to enhance students' technical abilities. It also underscores the need for educators and organizers to stay up-to-date with the latest trends and tools in the field and incorporate them into the curriculum. Additionally, one community organizer expressed their surprise at the students' expertise and familiarity with topics like climate change and pollution. This experience underscores the importance of acknowledging and valuing the knowledge and skills that students bring to the learning process. It also highlights the need for educators and organizers to create opportunities for students to share their knowledge and learn from one another.

One of the reasons why one community organizer said they were really impressed by the exceptional professionalism of the students was because they really enjoyed the face-to-face interaction and building personal relationships with students. This was highlighted by one community organizer, who enjoyed the first meeting being in person and getting to know the students. This reason emphasizes the significance of establishing a positive and supportive learning environment that fosters personal connections and rapport between educators, organizers, and students.

Another reason that emerged from the analysis was the creativity of the students. One community organizer explained that working with students allowed for more creativity since they were not bound by the limitations of money and time that come with being in the workforce. This reason highlights the importance of creating a safe and supportive environment where students can explore their creativity, take risks, and think outside the box. It also underscores the need for educators and organizers to provide students with the tools and resources they need to unleash their creativity.

One community organizer was most surprised by the students professionalism because of the initiative and interest that students took in the learning process. One community organizer expressed their surprise at the students' interest in learning about the organizations and taking ownership of the project. This community organizer stated,

> I was pleasantly surprised by the students' enthusiasm in learning about the organizations and how they took the initiative to drive every part of the project forward, from asking questions to completing tasks.

This quote emphasizes the importance of empowering students and fostering a sense of agency in their learning process. It also highlights the need for educators and organizers to create opportunities for students to take initiative and pursue their interests.

Lastly, one community organizer was most surprised by the student's professionalism because they enjoyed the symposium. One community organizer expressed their surprise at the format of the symposium, which allowed for more conversation and interaction. The community organizer's thoughts about the student's exceptional professionalism highlights the importance of creating engaging and interactive learning experiences that promote collaboration, communication, and critical thinking.

Question 2: How did the students incorporate their knowledge from experiences, or community knowledge, or academic knowledge into the research project? For example, what new information did you learn about the students' lives through this project?

During my conversation with the four community organizers, I asked them how students incorporated their knowledge from experiences, community, and academic knowledge into the research project. I was particularly interested in learning what new information they discovered about the students' lives through the project. All of the community organizers stated that students incorporated their experiences and community knowledge by sharing their struggles with systemic inequality, such as gentrification, food insecurity, flooding, zoning, and inadequate schools.

One community organizer mentioned how, during the brainstorming process of creating their research question, the students were very open about their personal lives and situations. This community organizer stated,

> The students were very forthcoming about their own situations and personal lives, including events happening in their own neighborhoods. As we conversed, they made connections between their experiences and con-

> cepts such as gentrification, which helped us to understand each other better while brainstorming and become more connected to the issues we discussed.

This allowed them to make connections between their experiences and the issues they were discussing. For instance, a community organizer discussed how one student shared how their neighborhood was affected by zoning laws and what they were able to build. Another student responded by sharing their experience of trying to do the same thing in their neighborhood but failing. This led to a deeper understanding of the impact of zoning on their day-to-day lives.

Another community organizer stated that the students also shared their experiences with systemic inequalities, such as flooding in their neighborhoods, which was helpful in understanding the local watershed. This community organizer said,

> I think it's important to emphasize that these are neighborhoods the students are intimately familiar with. During our conversations, the students shared valuable insights such as, "I know this road always floods when it rains," providing us with knowledge about the watershed that we, as an organization, might not have known. The students are the ones who live in these neighborhoods and have first-hand knowledge of the area, such as which storm drains are likely to flood during a rain event. These personal experiences were invaluable and helped to enrich our discussions.

However, some topics were more sensitive to discuss, such as food insecurity. One community organizer mentioned that, despite learning about a student's experience with food insecurity, they did not feel comfortable asking students about it directly. They felt that it was not something that should be asked about.

Question 3: What's the possible impact that your project could have on your organization and the people that you are trying to support? Can you give a specific example?

All four community organizations expressed interest in using the StoryMaps to bring more resources to their community, whether it be by sharing data analysis with

government officials (one), raising awareness of community issues (one), or making decisions within their own organizations (three).The ArcGIS StoryMap is an interactive data visualization tool that allows users to create a website for sharing data. The StoryMaps created by the students are essential for supporting community organizations by providing an interactive way for community members and organizers to access this data.

One community organizer who wished to share data with government officials said,

> I think for my work, especially when I go out to different neighborhoods and meet city councilors, the mayor's office, and city staff, we bring in a lot of our resources and data, as well as analysis that we do for various issues.

Another community organizer noted the impact of the StoryMaps for raising awareness:

> The impact and use of the StoryMap would be really helpful for when I go out and talk to different neighborhoods about inland flooding and about resources in their area that might be affected. These are important conversations to build awareness around, and visuals like the ones that the students put together will be really helpful.

Three community organizers expressed hope that the StoryMaps could help them make decisions within their own organizations. One organizer said,

> We are going to use this project to help us organize and prioritize the outreach that we've been doing to our current homeowners. With these maps that literally show the number of trees and the amount of green space, we can prioritize those efforts to start in areas that may need it the most.

Another organizer commented on the potential for future development, saying,

> We will definitely be keeping in mind that certain neighborhoods have this many grocery stores or parks. We serve families, so that is definitely

> something we want to keep in mind. Our development would definitely benefit from the results of this project.

The third organizer spoke about using the data visualizations to address food insecurity, saying,

> Being smarter about which organizations get food is helpful. These data visualizations will be used to find the neighborhoods with the biggest meal gap that can be addressed by proximity to food resources.

Question 4: What was your favorite aspect of this project?

All community organizers expressed that their favorite part of the project was working with the high school students. Four responses fit into this category, indicating that it was a significant aspect of the project for the organizers. One community organizer particularly enjoyed listening to other community organizers' projects. Another organizer's favorite aspect was being able to work with the students and seeing their progress throughout the project. This organizer expressed,

> I really enjoyed watching the students make the project their own. I think, when we first had our conversation we were leaning towards other neighborhoods. We had a lot of different factors that we could have analyzed. After, students spent a lot of time thinking through it, and how they could actually make it their own. And to see the results was definitely very, very impressive.

Similarly, another community organizer found it interesting to work with high school students due to their unique perspective and energy. This community organizer stated, "Having such varied interests. So I think it was just really fun to work with students of that age." Another community organizer appreciated the personal and collaborative experience of working face-to-face with the students.

One organizer enjoyed hearing the student's perspectives during the symposium and found value in the insights and knowledge the students brought to the table. This community organizer stated that their favorite aspect of the project was listening to

the students present their research projects via ArcGIS Story Maps. This person stated, "My favorite part was hearing them say in their own words, as best they could, sort of what they were thinking about."

Lastly, one community organizer enjoyed hearing ideas from the other community organizers and learning about other community organizations involved in the project. This organizer stated,

> That was nice to also hear what some of the other nonprofits or community groups that you are working with, that I've never heard of before. And hear them also, you know, brainstorm their sessions.

Overall, the community organizers expressed appreciation for the opportunity to work with the students and for the research symposium, which allowed for a collaborative and knowledge-sharing experience. These themes suggest that the project was successful in providing a valuable learning opportunity for both the students and community organizers involved.

Question 5: What was your least favorite aspect of this project?

All of the community organizers expressed a desire for more time to work with the students on this project. In particular, two organizers wished for a clearer outline of deadlines for different tasks. Additionally, two organizers mentioned that there were revisions made to the survey that they wished they had known about earlier.

A common theme that emerged from the responses was the need for a better system to keep community members informed (four). Two participants mentioned that they would have liked more time to plan and to have a better understanding of what tasks needed to be completed. This suggests that community members may have wanted to be more involved in the project and have more opportunities for communication and collaboration with the students.

All of the community organizers noted a lack of interaction with the students, and one participant specifically mentioned wanting more opportunities to engage with them. This highlights the importance of involving community members in the project and ensuring that they have opportunities to work directly with the students.

Finally, another theme that emerged was related to the survey. One participant suggested that a shorter survey with only three questions would have been preferable, while another organizer mentioned that clearer guidelines on who was responsible for collecting data would have been helpful. This suggests that some community members may have found the survey confusing, and that more guidance could have been provided to ensure its effectiveness.

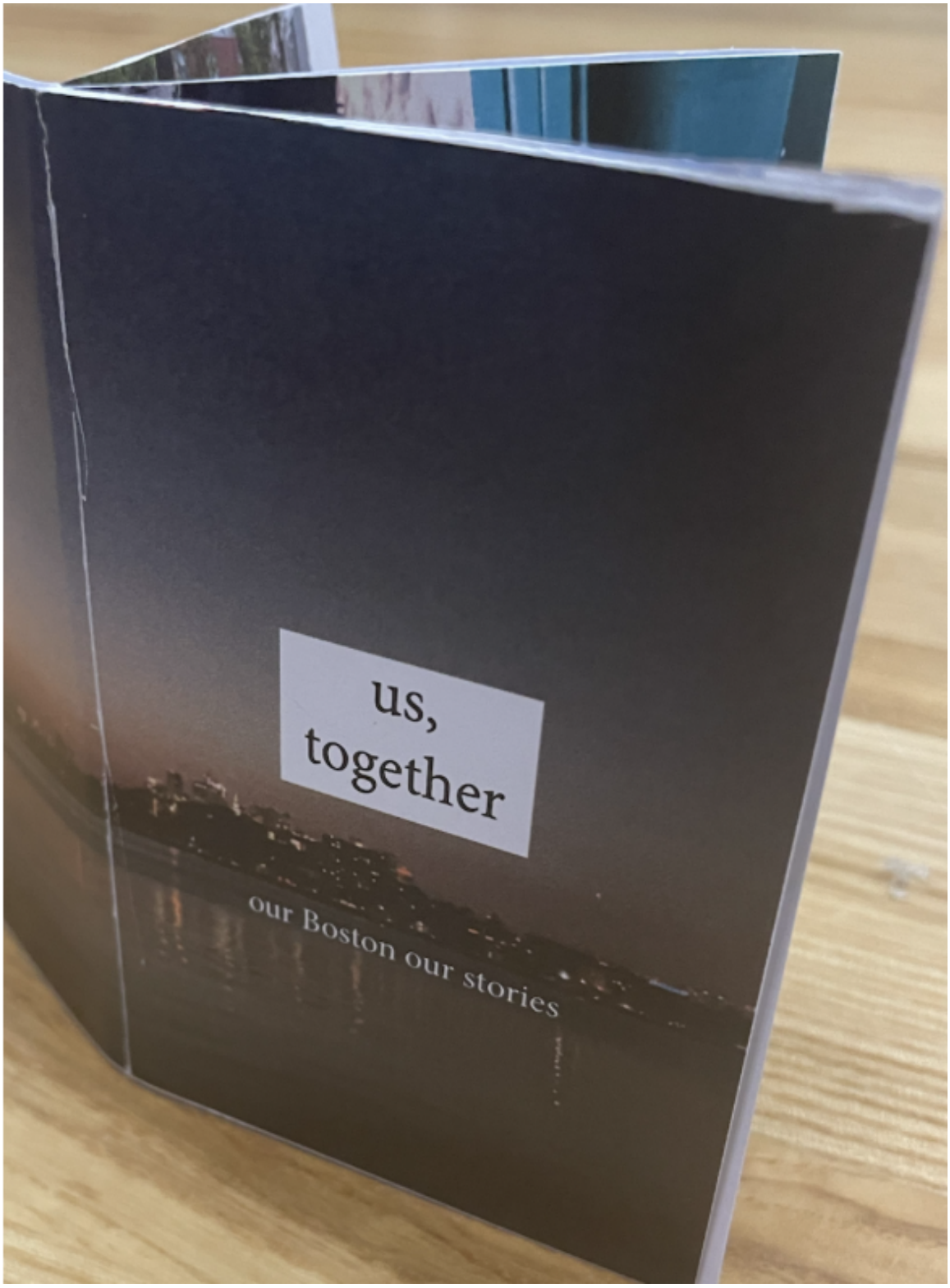


Figure 7-3: Habitat for Humanity Group Zine

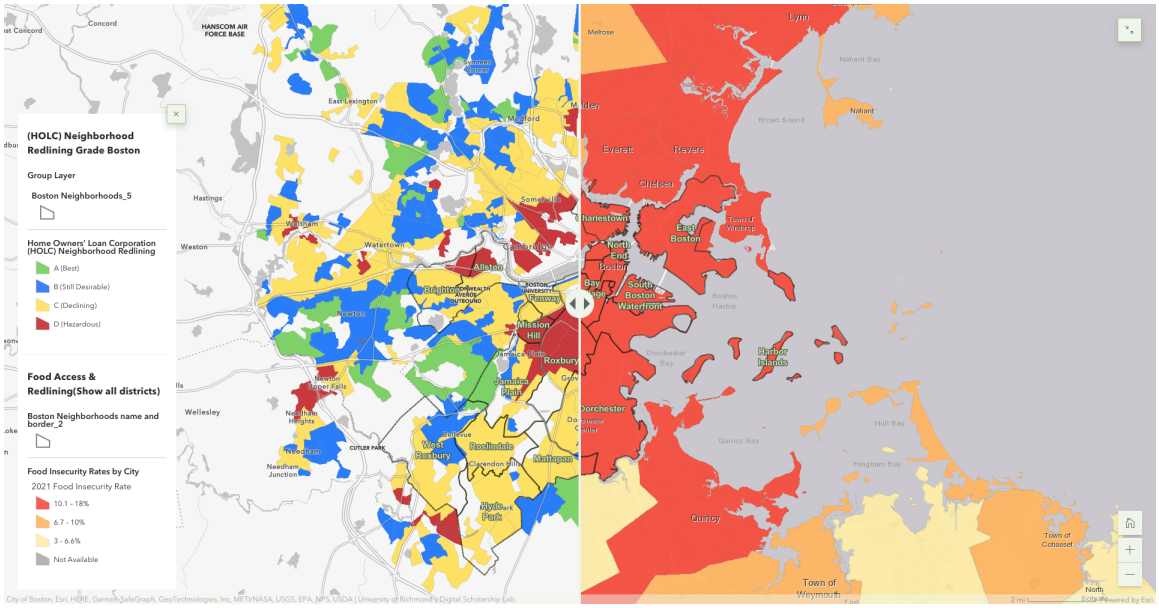


Figure 7-4: On the left, we can see the 1930s Home Owners Loan Corporation (HOLC) map of Boston, which clearly shows areas that were subjected to redlining. On the right, we have a map displaying the food insecurity rates for 2021. It is worrisome to note that most of the neighborhoods that were previously affected by redlining are now situated in towns with high levels of food insecurity.

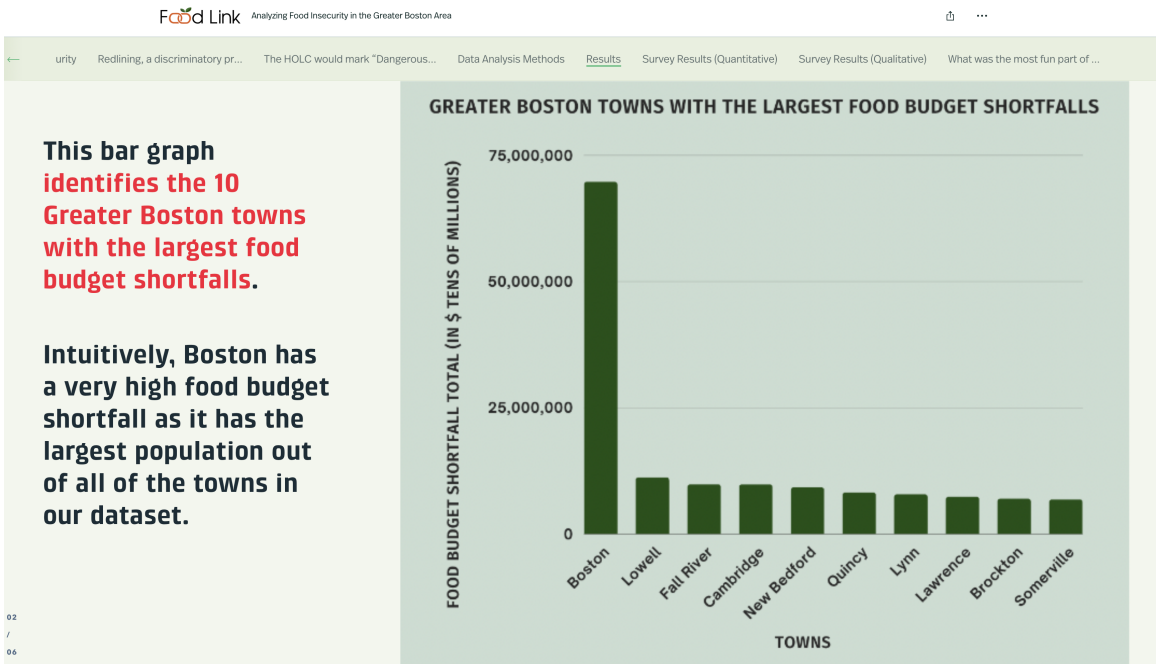


Figure 7-5: This bar graph identifies the 10 Greater Boston towns with the largest food budget shortfalls. Intuitively, Boston has a very high food budget shortfall as it has the largest population out of all of the towns in our dataset.

Figure 7-6: The Food Link group's tote bag, designed to raise awareness about food insecurity.

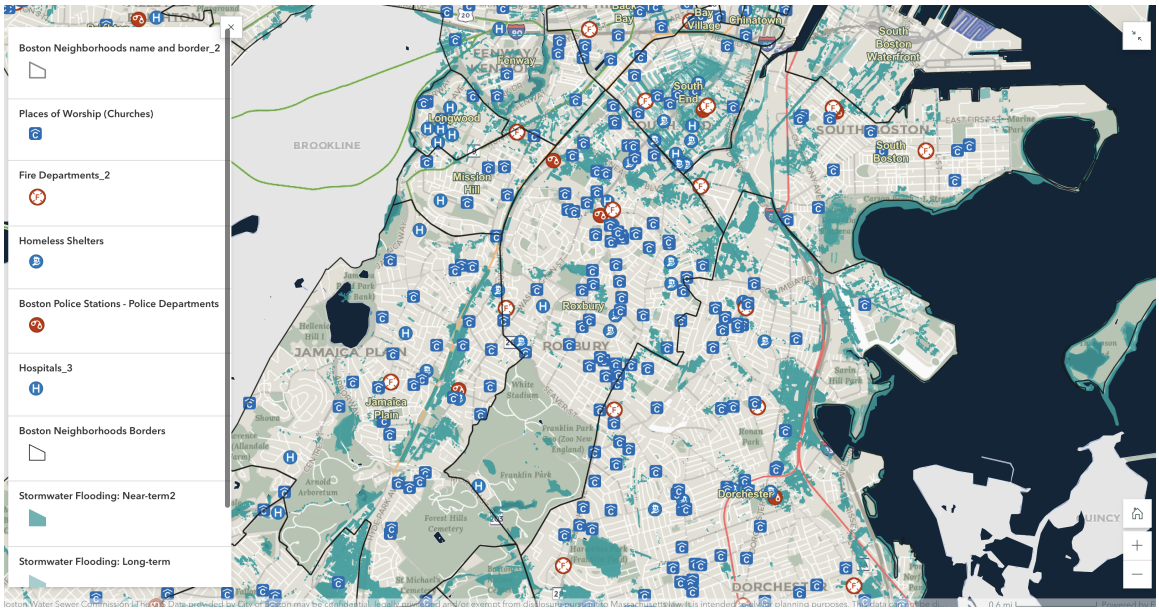


Figure 7-7: This ArcGIS Map investigates the community assets situated in Boston neighborhoods that are susceptible to stormwater flooding from the 2030s-2050s and the 2070s or later.

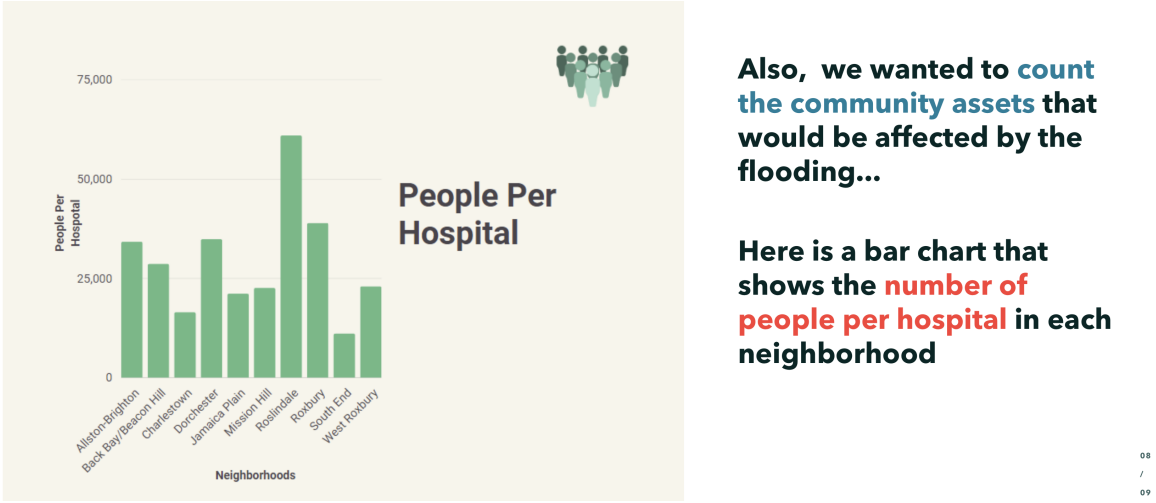


Figure 7-8: This bar chart illustrates the population-to-hospital ratio for each neighborhood in Boston.

Figure 7-9: CRWA's sticker, designed to raise awareness about environmental injustice.

8

Significance and Enhancements of the Data Activism Program with Boston African American Students

In this section, I will delve into the significance of the second data activism program and explore potential areas for improvement. Students demonstrated an impressive range of skills within a mere 10-week period, creating, analyzing, and visualizing data sets, surveys, and maps that made a tangible impact on their community. Moreover, other local organizations have expressed interest in using these ArcGIS StoryMaps and sharing their outcomes with others. This highlights the urgent need for more educational programs that truly invest in African American students by providing them with greater independence in choosing what they learn and giving them the

opportunity to apply their knowledge to real-world problems. Such initiatives emphasize the importance of offering a more flexible curriculum that allows students to demonstrate their knowledge and skills in the context of their communities. In fact, all of the community organizers have praised the students for their exceptional data visualizations and nuanced understanding of the lived experiences of people in their neighborhoods.

8.1 Significance

Now, I will reflect on the significance of the second data activism program and emphasize several noteworthy findings that emerged from the study. The projects devised by students and community organizers proved to be highly advantageous and profoundly captivating. Both students and community organizers expressed satisfaction with these projects, as they will directly contribute to the improvement of the neighborhoods represented by some of the students. First and foremost, the curriculum successfully fostered an increase in confidence among African American students, enabling them to integrate their own lived experiences into data activism projects. Furthermore, the study revealed a significant increase in the percentage of students who not only comprehended how to utilize their academic achievements and data science skills, but also recognized the potential of these abilities to support and uplift their communities. This newfound understanding empowered them to become active agents of change, employing their skills for other African Americans.

A crucial element of this curriculum that deserves special attention is the empowerment experienced by students, allowing them to authentically express themselves within the learning environment. This empowerment was facilitated through a range of factors, including thought-provoking lessons that encouraged open discussions about their diverse interests and passions, as well as fostering a radically inclusive classroom atmosphere. Firstly, activities were designed to encourage students to discuss their interests outside of school with their peers, creating a sense of community. For example, the "Intersectionality Data Drawing" activity provided

an opportunity for students to share different aspects of their lives. Moreover, the interviews revealed how students seamlessly incorporated their interests in art, photography, and writing into the class. Extensive research in the field of education consistently affirms the concept that when classroom activities empower students to integrate various facets of their daily lives into their studies, it significantly enhances the meaningfulness of the topics being taught.

Moreover, the nurturing classroom environment played a pivotal role in empowering students to incorporate their community knowledge and personal experiences into their projects. Specifically, three students emphasized the importance of being surrounded by fellow African Americans, as it reassured them that they were not alone in confronting different forms of racism. Their collaboration with supportive community organizers further enhanced their overall experience.

The combination of encouraging students to bring their full selves into the curriculum and focusing on topics related to their personal hardships, trials, and tribulations contributed to their understanding of how to use their academic success and data science skills to support their communities. This is particularly noteworthy since there are limited data science and computing curricula that actively encourage African American students to openly discuss their experiences with racism, redlining, or gentrification. During interviews, both students and community organizers highlighted how students took the lead in the projects because they possessed an unparalleled expertise in their communities, enabling them to validate and analyze the data in ways that community organizers or online resources could not.

Overall, these findings highlight the importance of designing projects that empower African American students to embrace their complete identities in the field of computing and delve into topics that resonate with their personal experiences. Through the amplification of student voices and the utilization of their expertise, the second data activism program effectively fostered a profound comprehension of how academic achievements and data science can be leveraged to address the specific needs of their communities. Furthermore, it is important to highlight that students made a tangible real-world impact through their projects by supporting community

organizers in their work.

8.2 Improvements

This section will discuss how I will enhance the second data activism curriculum in two main ways. The first improvement centers around providing students with additional administrative assistance and additional support from community organizers to maximize the impact of their projects. Second, the activities leading up to the final projects and the final project will be refined, ensuring a more effective learning process.

To enhance administrative and community organizer support and provide ample practice in data activism, the next program is planned to be offered during the summer. This scheduling decision will offer students the opportunity to participate in-person at the Media Lab for four days a week, four hours a day, spanning an eight-week period. This extended duration ensures that students have sufficient time to practice all aspects of the CPAR process and familiarize themselves with the necessary tools before collaborating with community organizations.

By dedicating more resources, we can facilitate extensive engagement, with community organizers being present for at least two days a week. To further support students in developing impactful projects, a full-time administrative staff member might be included in the program. Their presence will provide ongoing assistance and guidance throughout the project development process. To foster better collaboration between students and community organizers, efforts will be made to introduce them earlier in the process. This will facilitate stronger partnerships and improve the overall synergy between students and community organizers. By implementing these measures, the second data activism curriculum aims to provide greater administrative and community organizer support, maximize student engagement, and cultivate impactful projects that make a real-world difference.

Moreover, some of the activities will undergo enhancements to effectively tackle the challenges encountered by some students who did not know how to specifically

integrate data activism into their daily lives. To achieve this, a dedicated lesson will be created to demonstrate practical ways to incorporate data activism into both future careers and daily activities. In consideration of students who are new to coding, it is of utmost importance to prioritize the development of additional resources that offer prompt feedback and assist students in efficiently debugging their code.

In conclusion, the enhancements planned for the second data activism curriculum aim to provide students with comprehensive support and resources to maximize their impact and learning experience. By offering extended in-person sessions during the summer, students will have ample time to practice their data activism skills. Through increasing administrative and community organizer support, we aim to foster consistent collaboration between students and community organizations, creating stronger partnerships and enabling the development of impactful projects. Additionally, specific activities within the curriculum will be carefully refined to ensure that all students acquire the necessary knowledge and skills to effectively integrate data activism into their lives. Through these improvements, the next data activism curriculum will empower more students to be influential data activists.

9

Discussion

In this discussion section, I will showcase how the analysis of the interviews, students' projects, and surveys from both data activism programs address my research question:

> How do the data activism curricula prepare students to engage in data activism? Additionally, what is the impact of implementing different data activism curricula on students' proficiency in each liberatory computing pillar?

I evaluated the efficacy of both curricula in preparing students for data activism, using the five pillars of liberation as a framework. The five pillars were crucial in enabling students to develop data activism projects. Moreover, it is worth highlighting the significant increase in the percentage of students who now understand how

they can utilize their academic success and data science skills to support minoritized communities.

9.1 Sound Racial Identity

A sound racial identity is relevant to answering my research question as it helps students to better understand themselves and their relationship with systemic injustices and challenges faced by their racial group. This understanding may motivate them to engage in data activism and integrate it into their daily lives. By fostering the development of a strong racial identity, students gain a deeper understanding of how their racial group has been historically impacted by systemic oppression and marginalization. This heightened awareness enables students to recognize the specific areas where data activism is crucially needed. Moreover, students with a sound racial identity may be more likely to incorporate data activism into their daily lives, feeling a greater sense of responsibility and urgency to address issues affecting their communities. Thus, cultivating a sound racial identity is vital for students to become effective data activists, as it not only boosts their own confidence but also enables them to provide support and advocacy for others within their racial community

The ideal outcome of the program is for students to have a deeper understanding of the persistence of racism, recognize the importance of their race in their identity, and feel positively about their racial identity. The two data activism curricula focused specifically on African Americans, an often overlooked perspective in traditional data science curricula. Through these activities, students developed a strong racial identity that supports their community, themselves, and their learning. The discussion highlights how the program enhanced students' understanding of the persistence of racism against African Americans and the importance of their racial identity. The results of the study are based on surveys, interviews, and projects. Some students were prepared to engage in data activism as they felt that being African American was an essential part of their identity and gained confidence about being African American after taking the class. Additionally, students integrated data activism into their lives

by working on projects relevant to their race.

One's ability to recognize and acknowledge the existence of negative beliefs about African Americans, commonly referred to as low public regard, plays a crucial role in developing a sound racial identity and actively engaging in data activism. The first data activism program included activities such as the "Intersectional Data Analysis on Gun Violence" and "Intersectional Data Analysis on Affirmative Action", which engaged students in discussions and projects that increased their understanding of systemic racism against African Americans. In the "Intersectional Data Analysis on Gun Violence" activity, all 12 students demonstrated a comprehensive understanding of the connection between housing, racism, and policing through their participation in classroom and online discussions, as well as in their intersectional data analysis. During the "Intersectional Data Analysis on Affirmative Action" activity, eight out of nine students discussed the necessity of Affirmative Action due to the lasting impact of racist laws and slavery through their online discussion posts, classroom discussions, and intersectional data analysis. Additionally, in the "Systemic Justice" capstone projects, some students showed a profound understanding of systemic oppression through their background research, intersectional data analysis, and data drawings, while others exhibited areas for growth.

The first program positively impacted certain aspects of students' sound racial identity, such as increasing their awareness of racism against African Americans as evidenced by their projects and slightly improving their ability to acknowledge their race as a crucial aspect of their identity according to survey results. However, it is unclear whether the program led to an increase in positive emotions related to their racial identity, such as gratitude, pride, happiness, and awe based on the survey data. Therefore, further analysis with a larger sample size is needed to draw more definitive conclusions. Overall, the first data activism program has the potential to enhance certain components of students' sound racial identity.

Next, I will be presenting the results from the second program and evaluating its impact on students' racial identities. One crucial aspect of having a strong racial identity is being aware of the detrimental effects of systemic racism on African Americans.

Based on the responses to the first and third questions in the high school interviews, it appears that the second data activism curriculum had a positive impact on increasing students' awareness of systemic racism against African Americans. Students were more aware of different forms of racism, such as AI bias and redlining. Furthermore, it is worth noting that some students reported an increase in confidence related to their racial identity as a result of their collaboration with other African American individuals within the program. By working alongside peers who share similar racial backgrounds and experiences, students found a supportive and empowering environment that nurtured their racial identity. The curriculum provided a safe environment for students to collaborate with like-minded peers, leading to the development of a stronger awareness of systemic racism against African Americans.

Furthermore, the post-surveys from the second program revealed that a greater awareness of racism could result in more negative and positive feelings about their race. After the data activism program, students expressed more negative emotions about being African American. Nevertheless, there was a slight increase in positive emotions about their racial identity recorded after students took the class, suggesting that the curriculum might have had a positive impact on students' attitudes towards their racial identity. In addition, the responses to the third question from the high school interviews indicate that the curriculum had a positive impact on the majority of students' confidence in their racial identity, enabling them to be better activists even if they experience more negative emotions.

Another aspect of the second program evaluated students' belief in the importance of race as a part of their identity. I will discuss how there was a slight increase in the number of students that saw their race as an important part of their identity through student surveys and community organizer interviews. The post-surveys showed a slight increase in the number of students who felt that race was an essential aspect of their identity. However, it is worth noting that none of the students disagreed with the statement after finishing the second program. The community organizers reported that students were able to connect their personal experiences with the racial disparities they observed in the data. For instance, one student talked about living

in an area that frequently floods, which is also a neighborhood with a large African American population in Boston. This project allowed students to use their experiences as African Americans to inform their research, empowering them to engage in data activism and address systemic oppression through data science.

Based on the interviews, surveys, and projects, it can be concluded that the students' awareness of the impact of systemic racism on African Americans has improved, as well as their confidence in their own race. While there was a slight increase in the students' positive feelings about their identity as African Americans and their belief that it is an important part of their identity, the program has undeniably equipped them with an in-depth understanding of African American history and a comprehensive awareness of the challenges faced by the community in accessing resources. These outcomes the program's efficacy in various dimensions of students' racial identity and in cultivating critical thinking regarding African American experiences. These skills are vital for constructing a more equitable society through data activism, where students leverage their lived experiences to inform their data-driven advocacy efforts.

9.2 Critical Consciousness

Having a critical consciousness is crucial for data activism, especially for African American students, because it helps them understand the existence and nature of injustice. Without this awareness, they cannot effectively address systemic oppression and transform society. In addition, students need to feel confident in their ability to mitigate oppression before taking action.

The three main components of critical consciousness are critical reflection, sense of agency (self-efficacy), and critical action. The survey, interviews, and projects assessed student's ability to critically reflect, while student's sense of agency and their ability to critically act were evaluated through interviews and projects. A key goal of the program is for each student to confidently showcase their newly acquired understanding of systemic racism. For instance, they might delve into the disproportionate impact of redlining on African Americans, shedding light on challenges such as food

insecurity. Moreover, it is crucial for students to articulate how the data activism program has enhanced their confidence as data activists, acknowledging their heightened sense of agency in driving change through data-driven advocacy.

In both data activism programs, all students demonstrated an increase in critical consciousness regarding African American history. The study results, based on surveys, interviews, and projects, show that all students increased their critical reflection skills by citing examples of systemic racism such as redlining and gentrification. Furthermore, all students were able to complete their final data activism projects and present them, indicating an increase in their ability to critically act. Finally, students felt an increased sense of agency because they were less intimidated by coding after taking the data activism class. Overall, the responses indicate that the data activism curriculum effectively prepared students to engage in data activism by raising awareness and encouraging meaningful action to address issues of injustice faced by African Americans.

The first data activism curriculum was successful in increasing students' critical reflection and action skills, as demonstrated by their active participation in online and group discussions, surveys, and the completion of their final projects. The curriculum's focus on intersectionality, AI bias, and enduring effects of systemic issues such as slavery and redlining helped students develop a critical lens for analyzing issues of inequality affecting African Americans. The students' demonstrated understanding of these concepts suggests that the curriculum effectively taught them about the potential for AI bias and its negative impact on neighborhoods with predominantly African American and Latinx populations. The students' final capstone projects demonstrated their ability to apply critical skills to analyze topics they were passionate about and develop solutions to address systemic injustices, such as the racial disparities in low birth African American babies. These findings confirm the effectiveness of the first data activism curriculum in equipping students with knowledge and skills for data activism. However, further analysis of their surveys is necessary to determine whether the first program significantly increased students' sense of agency to become data activists.

The second data activism program facilitated an increase in students' ability to critically reflect, as demonstrated by their surveys, interview responses and final projects with community organizers. The survey results indicate a noteworthy trend towards students believing in technology's potential to diminish racism. In particular, during the interviews, students were asked about their insights on the project's examination of inequality against African Americans and their inclination to delve deeper into the subject matter. The students reported gaining a deeper understanding of the ongoing challenges and injustices faced by African Americans in accessing resources. Additionally, some students expressed a desire to learn more about the issues that African American women face in not being recognized by some facial recognition algorithms. Overall, the second data activism program has effectively equipped students with the necessary skills to research systems of oppression through various frameworks, including intersectionality.

In addition, the second program increased students' sense of agency, as they felt less intimidated by coding after completing the curriculum. During the interviews, all students who were initially intimidated by coding reported feeling more confident in their ability to use it to mitigate systemic oppression in the future. These responses indicate that the data activism curriculum successfully equipped students with the necessary skills and knowledge to engage in data activism with confidence.

Regarding critical action, none of the students from the second program had previously completed a data activism project. Nevertheless, all students completed the final project and presented it to highly esteemed education officials, such as the Assistant Superintendent of Boston Public Schools. All three final projects discussed how systemic issues disproportionately affect African Americans, with some students specifically addressing the harmful effects of redlining on inland flooding, food insecurity, and housing inaccessibility in neighborhoods with a significant African American population, such as Roxbury and Dorchester. In conclusion, the students' successful completion of the final projects and their presentation to esteemed education officials demonstrated their increased confidence and ability to engage in critical action through data activism.

Through both data activism programs, students gained a better understanding of the ongoing challenges and injustices faced by African Americans in Boston, as well as experience using data activism as a form of critical action, which increased their confidence in using skills such as coding. They also learned about the potential of AI to perpetuate or address these inequalities, highlighting the importance of developing and implementing AI in ways that promote justice and recognize African American women. In conclusion, the second data activism program provided students with a valuable opportunity to tackle issues of injustice impacting African Americans through a comprehensive four-week capstone project in collaboration with community organizers.

9.3 Liberation Centered Academic Identity (LCAI)

Cultivating a liberation-centered academic identity is crucial for data activism, particularly for African American students, as it empowers them to believe in their intelligence and utilize it to uplift their community. A LCAI encompasses two key components: an Embedded Achievement Philosophy, where students recognize their intelligence, and an Achievement for Freedom Philosophy, where students understand that their educational achievements should contribute to collective transformation. The surveys assessed students' Embedded Achievement Philosophy by measuring their self-perceived proficiency in coding skills and their capability to integrate their diverse interests into their projects. To evaluate their Achievement for Freedom Philosophy, the surveys and interviews gauged their agreement with the statement "I know how to use my academic success to address racism for myself, community, and other minorities" and their plans to incorporate data activism into their daily lives. Ideally, both programs would foster increased confidence in coding skills, the ability to incorporate diverse interests into projects, heightened awareness of using academic success to support others, and a commitment to integrating data activism into everyday life.

The study's findings from both programs, incorporating analysis of surveys, inter-

views, and projects, reveal several noteworthy outcomes. Firstly, a larger proportion of students demonstrated enhanced confidence in their coding skills, as indicated by survey responses. Secondly, through analysis of projects and interviews, it was observed that students successfully integrated diverse subjects into their projects, showcasing their ability to apply interdisciplinary knowledge. Furthermore, the surveys highlighted a significant increase in awareness among students regarding the potential of leveraging their academic skills to address issues of racism. Lastly, interviews from the second program revealed that all students expressed a strong desire to continue incorporating elements of data activism into their lives beyond the program's duration, showcasing their sustained commitment to the cause. Overall, the responses indicate the effectiveness of the data activism curricula in preparing students for data activism by fostering their motivation to pursue academic achievement as a means of advancing racial liberation.

The first data activism curriculum proved to be successful in enhancing students' Embedded Achievement Philosophy. This was evident through the variety of topics they confidently chose during their final projects and their increased confidence in coding skills following participation in the data activism class, as indicated by survey results. The diversity of topics explored in students' "Systemic Justice" capstones exemplified their ability to apply data activism concepts to address various social justice issues of their choice, such as housing, healthcare, gun violence, and education. Moreover, the incorporation of data drawings and background research into their final projects allowed students to leverage their other interests and strengths beyond coding. For instance, in the capstone projects, one student created a powerful depiction of an African American baby to raise awareness about the profound disparities in low birth weights among infants of African American descent. These findings affirm the efficacy of the first data activism curriculum in empowering students to feel competent in coding and enabling them to integrate their additional strengths and interests into their final projects.

Additionally, the first data activism curriculum proved successful in fostering students' Achievement for Freedom Philosophy. Students were asked to rate their level

of agreement with the statement "I know how to use my academic success to address racism for myself, community, and other minorities" on a scale of one (strongly disagree) to seven (strongly agree). The findings indicate that the curriculum effectively equipped most of the students with the confidence and understanding necessary to leverage their academic success in supporting their community. It is essential for students to believe in their capacity to utilize their academic skills to uplift and empower their community, especially within the context of addressing racial inequalities.

The second data activism curriculum proved to be highly effective in enhancing students' Embedded Achievement Philosophy. This was evident through various indicators, including the students' increased confidence in coding skills as observed in surveys, their successful integration of other interests and strengths, such as art, into their projects, and their ability to incorporate personal experiences and community knowledge into their final projects, as revealed in interviews with community organizers. Each student exhibited the capacity to integrate their personal interests into their projects, thereby showcasing the remarkable diversity of their passions and pursuits throughout the course. Also, the program allowed students to incorporate their main interests, with 10 students expressing a focus on art, three students highlighting a passion for history, and an additional three students emphasizing their interest in writing. As part of the second data activism program, students created impactful projects like tote bags with block prints displaying the message "Close the Meal Gap" and zines that visually depicted the accessibility or inaccessibility of specific resources in Boston. Furthermore, each student skillfully utilized their writing skills and historical knowledge to construct their final data activism projects. These projects have not only been utilized by the community organizers but will also continue to serve as valuable resources in their ongoing work. These outcomes emphasize the crucial importance of students feeling confident in their academic abilities.

During conversations with four community organizers, I explored how students incorporated their knowledge from experiences, community, and academic sources into their research projects. I specifically aimed to understand the new insights gained about the students' lives through this process. The community organizers highlighted

that some students effectively incorporated their experiences and community knowledge by sharing the challenges they face due to systemic inequality, such as gentrification, food insecurity, flooding, zoning, and inadequate schools. These findings further emphasize the success of the second data activism curriculum in encouraging them to integrate their additional strengths and interests into their final projects, as well as facilitating the sharing of community knowledge and personal experiences in their projects and presentations.

Furthermore, the second data activism curriculum significantly fostered students' Achievement for Freedom Philosophy. Students were asked to rate their level of agreement with the statement "I know how to use my academic success to address racism for myself, community, and other minorities" on a scale of one (strongly disagree) to seven (strongly agree). The results indicated a substantial increase in the number of students who recognized the potential of leveraging their academic skills to address racism. During interviews, all 17 students expressed a strong desire to utilize data activism to raise awareness about specific issues in their daily lives. While seven students expressed a broad interest in incorporating data activism by joining community organizations, undertaking research projects, volunteering at food pantries, enrolling in social justice classes, and practicing gratitude for what they have, the other 12 students presented specific ideas on how to employ data science and social justice in the future. These outcomes highlight the critical nature of students feeling confident and motivated enough to use their academics to support other African Americans.

By fostering confidence and motivation, the data activism curricula empowers students to embrace their potential as change agents, dedicated to improving African American communities through their academic pursuits. It is encouraging to observe a rise in the percentage of students who possess the knowledge and skills to utilize data science in mitigating racism. This progress contributes to the overarching mission of the data activism curricula, which is to foster a more just society.

9.4 Collective Obligation

Embracing a collective obligation is crucial for data activism, particularly for African American students, as it motivates them to act towards the needs of a shared collective and increases their ability to engage in action together. Group identification and group consciousness are two key components of collective obligation. Group identification refers to the extent to which an individual sees themselves as part of a specific group. Since a sound racial identity for African Americans involves believing in and feeling connected to a group known as African American, it aligns with the concept of group identity. The section on sound racial identity demonstrated the students' increased confidence in their racial identity through interviews.

In addition to group identity, group consciousness encompasses three essential elements: the belief that the group is deprived of power, the rejection of society's justifications for this deprivation, and the belief that pooling resources will help overcome obstacles. We assessed students' belief that African Americans are deprived of power and their rejection of society's explanations for racial disparities through their final projects. Also, we evaluated their belief that people should unite and pool their resources to eliminate the obstacles faced by individuals experiencing racism through surveys and interviews. Ideally, both programs would foster an increased belief among students that African Americans are deprived of power and a stronger conviction that people of color should collaborate and pool their resources to support those facing racism.

The first data activism curriculum proved to be successful in enhancing students' belief that African Americans are deprived of power and their rejection of the reasons society offers for why African Americans are treated poorly. Each capstone project effectively discussed how racism contributes to harmful effects on African Americans in various topics, including housing, healthcare, gun violence, algorithmic bias, and education. For instance, one student highlighted how different forms of racism and stereotypes result in the underrepresentation of African Americans in AP STEM classes. In terms of rejecting stereotypes and racist commentaries, ev-

ery project successfully challenged the societal explanations for African Americans' relative positioning to the dominant group in the aforementioned topics.

Furthermore, the first program successfully increased the student's belief that people should pool their resources to eliminate the obstacles faced by the group. There was a strengthened belief among students in the significance of people of color supporting one another to combat racism. However, there were no increases in the number of students who felt more confident in working as a team after completing the first program. These findings highlight the positive impact of the data activism curriculum on students' collective obligation.

The second data activism program further strengthened every student's belief in the power deprivation experienced by African Americans relative to the dominant group, as well as their rejection of the societal explanations for this positioning. During the final projects, each group collaborated with community organizers to address various issues, such as racial disparities in food insecurity, lack of support against inland flooding, and limited community assets, that highlighted the power imbalance faced by African Americans. For example, the group working with Food Link conducted data analysis, revealing a significant correlation between the highest food insecurity rates and food budget shortfalls in the 10 Greater Boston towns with a higher presence of Latinx, Black, and low-income populations.

Moreover, the students' projects showcased their rejection of the societal reasons given for the inferior positioning of African Americans, with each student connecting what they learned to the historical impact of redlining on the community. The Habitat for Humanity group, for instance, highlighted how redlining in Roxbury resulted in decreased investments, declining property prices, and elevated levels of violence, unemployment, and poverty. In addition, our assessment of student survey responses and interviews with students and community organizers demonstrated that students further developed their belief in the importance of pooling resources to overcome the obstacles faced by the African American community. The survey results indicated an improvement in the confidence of a few students in working as a team, and there was also a slight increase in the number of students who recognized the essential role of

people of color supporting one another to combat racism.

To gauge the students' experience of collaborating with community partners, I conducted interviews with 17 students. The feedback overwhelmingly reflected a positive overall experience, with students attributing their positive experience to the expertise and knowledge brought by the community partners. The collaboration was considered a significant aspect of the project by the organizers, who expressed enjoyment in listening to other community projects and witnessing the progress made by the students throughout the program.

In summary, both programs successfully strengthened every student's belief in the power deprivation experienced by African Americans relative to the dominant group and enhanced their rejection of societal explanations for this positioning. The projects conducted by the students, along with the survey responses and interviews, emphasized the importance of collective action and resource pooling in tackling racism and addressing the challenges faced by the African American community. These outcomes highlight the transformative potential of both data activism curricula in fostering a shared commitment to dismantling racial inequities as a collective.

9.5 Activism Skills

Possessing activism skills is crucial for data activism as it equips individuals with the necessary tools to create meaningful change. However, it is important to recognize that a willingness to address systemic racism does not automatically translate to knowing how to effectively combat systemic oppression. Technical activism skills encompass a range of abilities, including communication, collaboration, analysis, and technology literacy, all of which play a vital role in planning and executing activism strategies. The students' technical activism skills were assessed through surveys, interviews, and projects, providing a comprehensive evaluation of their abilities.

The primary goal of both programs was to enhance students' confidence in utilizing data science to combat racism, which was successfully demonstrated in the first program through the showcase of students' projects. In the second program, there was a

statistically meaningful increase in the number of students who agreed that they knew how to use data science to mitigate racism. Furthermore, students reported positive experiences during the second program, and their projects had tangible real-world impacts while collaborating with community organizers. These findings strongly indicate that the data activism curricula effectively trained students to leverage data science for social justice and advocate for minoritized communities.

In the first data activism program, students demonstrated improvement in various activism skills, including communication, critical thinking, creativity, and technology proficiency. Notably, the lessons on "Intersectional Data Analysis on Gun Violence in Boston," "Intersectional Data Analysis on Affirmative Action," and the "Systemic Justice" capstone showcased students' ability to apply their knowledge of data science and systemic oppression to domains such as AI bias in the criminal justice system and college admissions. Building on the knowledge gained from the curriculum, seven students conducted independent research on a systemic problem of their choice, performed intersectional data analysis, and created data drawings to raise awareness. Thematic analysis of student responses from these projects provided compelling evidence of the curriculum's effectiveness in empowering students to engage in data activism. They effectively addressed community issues, such as the lack of affordable housing in Boston and the underrepresentation in advanced placement STEM classes.

Through the "Systemic Justice" capstone project, students honed their communication and critical thinking skills by synthesizing information from various sources into documents that exposed biases within their data sets. Furthermore, all students adeptly utilized data visualizations and applied the data cleaning and visualization techniques taught to them. In terms of creativity, one student's data drawing, which depicted a baby, effectively emphasized the human aspect behind racial disparities in low-birth weight infants. The survey results indicated a notable improvement in students' technology skills, with an increasing number of students expressing their ability to use data science to mitigate systemic oppression to some degree. Collectively, these findings strongly support the notion that the first data activism curriculum effectively prepares students to employ data science for social justice and advocate for African

Americans.

The second program demonstrated notable improvement in various activism skills, including communication, critical thinking, creativity, and technology proficiency. Survey results indicated a statistically significant increase in the number of students who reported their ability to employ data science for mitigating racism. Furthermore, students expressed positive experiences collaborating with community organizations during interviews, and their projects had tangible real-world impacts through their collaboration with community organizers. Regarding technology skills, all students effectively utilized ArcGIS StoryMaps to present their information to the community, impressing community organizers with their ability to create compelling presentations from the data. The interactive map visualizations received positive feedback from organizers, as they allowed people to explore community assets in their respective neighborhoods in Boston.

In terms of communication skills, all students confidently presented their work to community members during the research symposium, and the community organizer from Food Link expressed enjoyment in listening to the students present their work in their own words. Creativity was evident as all students created data drawings to raise awareness about the issues they were passionate about. For example, one group designed 30 t-shirts and tote bags featuring block print stamps with drawings related to food, such as a box full of groceries with the statement "Close the Meal Gap," effectively raising awareness about food insecurity. Furthermore, in terms of critical thinking, some students mentioned how they were able to critically analyze systemic issues in their neighborhoods, such as gentrification and redlining, and realize that the challenges they faced were not random but rather systemic issues. Overall, the second program demonstrated notable improvement in technical activism skills, including increased ability to employ data science for mitigating racism, positive collaboration experiences with community organizations, impactful projects, and confident communication during the research symposium.

The second data activism curriculum effectively prepared students to engage in data activism by incorporating their personal interests, including art, history, and

writing, into their projects. Art played a crucial role in helping students communicate their message and convey their ideas, while the incorporation of historical context and personal stories added depth to the overall project message. Collaboration with community partners was a vital aspect of the curriculum, with students expressing gratitude for the expertise and guidance provided. Although some students desired more time with community organizers, their experience working with them remained positive. Overall, the curriculum successfully equipped students to engage in data activism by integrating personal interests and community partnerships into the learning process.

The students' final projects have served as compelling demonstrations of their exceptional communication, critical thinking, creativity, and data science skills. Moreover, these projects have showcased their ability to effectively utilize these skills to address and mitigate systemic oppression against African Americans. Both programs have successfully fostered students' confidence in utilizing data science for social justice and have demonstrated a significant increase in their ability to employ data science to mitigate racism. During the second program, students' collaboration with community organizations has yielded valuable benefits, beyond simply enhancing their understanding of real-world challenges. Through their collaborative efforts in their CPAR projects, students have made significant contributions to supporting and empowering their communities.

The responses from students' interview questions and final projects provide valuable insights into how the data activism curriculum encourages students to incorporate data activism into their lives. Students demonstrated an understanding of the ongoing challenges and injustices faced by African Americans, particularly regarding access to resources and recognition. The recognition of themes such as redlining and AI bias signifies their awareness of technology's potential to either perpetuate or address these inequalities. This data activism curriculum holds the potential to inspire students to become active and engaged citizens committed to promoting social justice through data activism. Moreover, working with peers of the same race was noted as a confidence booster by some participants. The project has also increased students'

awareness and education about racial identity and the challenges faced by African Americans. Some students's acknowledged the impact of geographical location and stressed the need for more representation of African Americans in data science. This curriculum demonstrates that investing in African American students benefits not only their personal growth but also the broader community. Furthermore, it highlights the power of experiential learning in the classroom and its ability to extend beyond raising awareness to provide students with direct impact opportunities in their communities.

10

Conclusion

To increase the representation of African Americans in computing and bring about meaningful change in society, it is necessary to design curricula that teach them the necessary liberatory computing skills. Simply providing lessons that focus on a few liberation tools is not sufficient, as this approach has been ineffective in the past. My framework of liberatory computing goes beyond acknowledging the existence of racism in the lives of African Americans; it prepares them to contribute towards building a more justice-oriented society. These are the first data activism curricula intentionally made for African American high school students, aimed at assisting them in transforming society.

Both curricula have demonstrated their effectiveness in addressing the underrepresentation of African American students in computing. In summary, my curricula showed that when students feel encouraged, needed, and are able to bring their full

selves, they are more likely to be invested in data science. A notable achievement of these curricula has been the successful motivation of a greater number of African American students to actively engage with data science. This positive outcome can be attributed to the inclusion of liberation tools within the curriculum design.

Firstly, the curriculum facilitates the development of a sound racial identity among African American students, empowering them to recognize their own capabilities in effectively utilizing data science. This process of identity formation nurtures confidence and self-efficacy, which are crucial factors in fostering sustained engagement in data science. Secondly, the curriculum nurtures students' critical consciousness, enabling them to perceive the activities as personally meaningful, authentic, and aligned with their values. By establishing connections between computational practices and real-life experiences and interests, students are more likely to view them as relevant and worthy of pursuit.

Furthermore, the sense of collective obligation generated when working with other African American students in the field of computing enhanced some students' feelings of belonging and acceptance. The presence of a learning community with shared experiences solidified their belief that they can be exceptional data activists by utilizing their own community knowledge and striving to support their community. One student expressed this sentiment by stating,

> While it's true that Black girls can do anything that a White guy can, I felt a stronger sense of affirmation while working with people who looked like me. Learning coding as a whole and going through the process has been an empowering experience.

Creating a space for African Americans to share their experiences of racism was truly empowering and nurturing for these students. This type of space is often not provided in schools, but these curricula provided the opportunity for these types of important discussions by encouraging students to ask questions and share their experiences with different forms of oppression. My decision to extend lessons and classroom discussions to accommodate students' desire to discuss their own experi-

ences with systemic oppression in relation to these topics was essential. For example, during the first program, students led a book club after normal class hours about one of the books that the class is based on titled, "Race After Technology", where students were able to discuss different forms of racism they have experienced and their concerns about how AI could amplify different forms of oppression.

Additionally, community organizers highlighted how students enjoyed creating their own projects and supporting their community. One community organizer stated, "I really enjoyed watching the students make the project their own. We had a lot of different factors that we could have analyzed, and to see the results was definitely very, very impressive". The community organizers expressed that they learned a lot from the students about different areas of Boston that had a vast amount of African Americans, such as Roxbury and Dorchester because the students knew more about these areas, since they were actual residents. The recognition from community organizers not only emphasized the importance of African American students in computing but also acknowledged how the students perspectives and community knowledge were essential for completing these projects. The students demonstrated their expertise in various ways that are often overlooked in a school setting.

Lastly, by introducing practical skills such as Python, Pandas, and ArcGIS, the curriculum demystified data science, alleviating the initial intimidation that students felt. Overall, these curricula have successfully addressed the underrepresentation of African American students by creating an inclusive and empowering learning environment. This environment fosters motivation, the development of a strong racial identity, critical consciousness, an academic identity centered on liberation, collective obligation, a range of activism skills, and the practical skills necessary for engaging with data science. A student stated,

> When I first heard of data science, I was a little worried about it because I never heard of anything like that. I did not know how to properly clean data or even look at it when there's so much of it or even properly organize it. But now I feel confident at actually looking at data, cleaning it, and making the data more understandable.

Moreover, this curriculum demonstrates that students can make a significant impact on society with their data science skills by collaborating with community organizers in need of support.

Data science provides an ideal platform for incorporating liberation tools, as it enables a comprehensive understanding of both quantitative and qualitative data. Through data science, we can analyze vast amounts of data, extract insights to inform our comprehension of social issues, and develop effective strategies to address them. Additionally, data science techniques enable the identification of patterns and correlations in data that may not be immediately apparent, leading to a more nuanced understanding of complex issues.

The inclusion of the Critical Participatory Action Research Framework (CPAR) provides students with a structure to incorporate their community knowledge and lived experiences into the data science curriculum. This curriculum stands out as the first of its kind, ensuring that students not only utilize their data science skills to comprehend quantitative data but also employ the CPAR framework to analyze qualitative data and understand different perspectives by incorporating surveys and interviews from community members.

In my work, I not only contribute to the existing literature on frameworks for societal transformation but also provide two distinct data activism curricula that empower students to create projects in support of community organizations. These curricula represent a crucial step towards achieving greater representation and justice in the computing field and mitigating systemic oppression. By equipping African American students with the necessary data activism skills, we empower them to contribute to the creation of a more justice-oriented society.

The liberatory computing framework should be implemented in every computing class to foster an inclusive and empowering learning environment. To ensure broader accessibility to this curriculum, our work will make a significant contribution to two MIT schoolwide programs: the Day of AI and FutureMakers, within the MIT RAISE Initiative (Responsible AI for Social Empowerment and Education). Both FutureMakers and Day of AI are dedicated to promoting AI literacy among students and

teachers, with a particular focus on underrepresented backgrounds from K-12. As part of these initiatives, I have developed teacher training materials for a selection of data activism activities specifically tailored for the Day of AI program. This will provide hundreds of teachers from around the world with an opportunity to learn about data activism and incorporate it into their teaching practices. The subsequent step involves gathering feedback from teachers who engage with the data activism curriculum. This valuable input will guide the development of guidelines for teaching data activism classes. These guidelines will be made available online, ensuring easy access for teachers and students who wish to delve into the field of data activism.

When I engaged in conversations with the students about data visualizations based on data about their communities, they perceived the data visualizations as a story due to their intimate familiarity with the community. For instance, the students were able to explain the cause and effect of certain trends of the data based on their lived experience. One empowered student expressed,

> Well, in this project, we had been focusing on just Roxbury and South Boston, so I had been able to share my own personal story, and also just re-verified information where we had been wondering was transportation really an issue, and I can attest to that. I can tell you how many healthy food places there and honestly verify the information, because I am a resident.

Essentially, the high school students could verify quickly whether a dataset was accurate or not because they lived in the neighborhoods that their final projects focused on. Therefore, it is imperative that we continue to encourage African American students to share their stories and make a difference in the world because they have expertise in their communities and know the solutions that are necessary to better society. It was disheartening to discover that many of these students had never taken a coding class, and this was their first exposure to data science. Nevertheless, I take pride in the fact that this class differed from others, as the African American students felt represented, supported, and able to bring their authentic selves into the

classroom. I strongly advocate for the implementation of more liberatory computing classes because of their potential to truly transform lives, not only for the students but also for everyone who can benefit from these data activism projects.

A

Pre and Post Interviews and Survey Questions

A.1 Data Activism Curriculum with Cambridge Students: Interviews and Survey Questions

A.1.1 Pre- and Post- Survey Questions for High School Students

1. Sound Racial Identity

    1. I sometimes feel the following negative emotions about being a member of my race

2. I sometimes feel the following positive emotions about being a member of my race (Gratitude, Pride, Happiness, Awe)

3. I think many of the stereotypes about my racial group are true. (1/Strongly Disagree - 7/Strongly Agree)

5. I see my race as an important part of my identity. (1/Strongly Disagree - 7/Strongly Agree)

2. Critical Consciousness

1. Technology can make racism worse. (1/Strongly Disagree - 7/Strongly Agree)

2. Technology can help decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

3. I won't go to prison if I don't do anything wrong. (No or Yes)

4. Different forms of slavery still exist today in the US. (True or False)

5. I am concerned about the use of data science in technology. (1/Strongly Disagree - 7/Strongly Agree)

6. Technology is always the best way to solve problems. (1/Strongly Disagree - 7/Strongly Agree)

3. Collective Obligation

1. I believe that it is essential that people of color help one another in order to decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

2. I believe people of all races should help decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

3. I know how to figure out what users and communities need. (1/Strongly Disagree - 7/Strongly Agree)

4. I know how to design technology that helps people that have identities that make it more difficult for them to succeed in society. (1/Strongly Disagree - 7/Strongly Agree)

5. I know how to work on a team. (1/Strongly Disagree - 7/Strongly Agree)

6. I know how to define a real world problem. (1/Strongly Disagree - 7/Strongly Agree)

4. Liberation Centered Academic Identity

1. I see myself as a computer programmer. (1/Strongly Disagree - 7/Strongly Agree)

2. I am good at coding. (1/Strongly Disagree - 7/Strongly Agree)

3. I am inherently smart. (1/Strongly Disagree - 7/Strongly Agree)

4. I want to learn things that will help me decrease racism and oppression. (1/Strongly Disagree - 7/Strongly Agree)

5. I know how to use my academic success to address racism for myself, community, and other minorities. (1/Strongly Disagree - 7/Strongly Agree)

5. Activism Skills

1. I want to expand my computer programming knowledge. (1/Strongly Disagree - 7/Strongly Agree)

2. I expanded my computer programming knowledge. (1/Strongly Disagree - 7/Strongly Agree)

3. How comfortable are you talking about race/racism? (1/Strongly Disagree - 7/Strongly Agree)

4. I know how I can use data science to end racism.(1/Strongly Disagree - 7/Strongly Agree)

5. I want to include data science in technology projects that I create. (1/Strongly Disagree - 7/Strongly Agree)

6. I know how to define a real world problem. (1/Strongly Disagree - 7/Strongly Agree)

A.2 Data Activism Curriculum with Boston African American Students: Interviews and Survey Questions

A.2.1 Post Interview Questions for Community Organizers

1. What was your favorite aspect of this project?
2. What was your least favorite aspect of this project?
3. What's the possible impact that your project could have on your organization and the people that you are trying to support. Can you give a specific example?
4. Are you interested in working with the students more or extending the program?
5. What surprised you about how class went?
6. How did the students incorporate their knowledge from experiences, or community knowledge, or academic knowledge into the research project? For example, what new information did you learn about the students' lives through this project?
7. How was the research symposium? Did you learn anything new about the students during the symposium?
8. What are the next steps for this project?
9. What would you like to say to the students that you worked with?
10. Would you recommend this program to other people and students?

A.2.2 Pre- and Post- Survey Questions for High School Students

1. Sound Racial Identity

    1. I sometimes feel the following negative emotions about being a member of my race (Other, Helpless, Guilt, Fearful, Angry, Fearful)

    2. I sometimes feel the following positive emotions about being a member of my race (Gratitude, Pride, Happiness, Awe)

3. I think many of the stereotypes about my racial group are true. (1/Strongly Disagree - 7/Strongly Agree)

5. I see my race as an important part of my identity. (1/Strongly Disagree - 7/Strongly Agree)

2. Critical Consciousness

1. Technology can make racism worse. (1/Strongly Disagree - 7/Strongly Agree)

2. Technology can help decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

3. I won't go to prison if I don't do anything wrong. (No or Yes)

4. Different forms of slavery still exist today in the US. (True or False)

5. I am concerned about the use of data science in technology. (1/Strongly Disagree - 7/Strongly Agree)

6. Technology is always the best way to solve problems. (1/Strongly Disagree - 7/Strongly Agree)

3. Collective Obligation

1. I believe that it is essential that people of color help one another in order to decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

2. I believe people of all races should help decrease racism. (1/Strongly Disagree - 7/Strongly Agree)

3. I know how to figure out what users and communities need. (1/Strongly Disagree - 7/Strongly Agree)

4. I know how to design technology that helps people that have identities that make it more difficult for them to succeed in society. (1/Strongly Disagree - 7/Strongly Agree)

5. I know how to work on a team. (1/Strongly Disagree - 7/Strongly Agree)

6. I know how to define a real world problem. (1/Strongly Disagree - 7/Strongly Agree)

4. Liberation Centered Academic Identity

    1. I see myself as a computer programmer. (1/Strongly Disagree - 7/Strongly Agree)

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    4. I want to learn things that will help me decrease racism and oppression. (1/Strongly Disagree - 7/Strongly Agree)

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5. Activism Skills

    1. I want to expand my computer programming knowledge. (1/Strongly Disagree - 7/Strongly Agree)

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    3. How comfortable are you talking about race/racism? (1/Strongly Disagree - 7/Strongly Agree)

    4. I know how I can use data science to end racism.(1/Strongly Disagree - 7/Strongly Agree)

    5. I want to include data science in technology projects that I create. (1/Strongly Disagree - 7/Strongly Agree)

    6. I know how to define a real world problem. (1/Strongly Disagree - 7/Strongly Agree)

A.2.3 Post-Interview Questions for High School Students

1. What have you learned about inequality against African Americans in this project?
2. How has this project impacted your motivation to broaden your knowledge of African American history and social justice?

3. How, if in any way, has this project influenced your outlook on your racial identity? Do you feel more confident in your race?
4. To what extent, if any, have you incorporated other interests, such as art into your project?
5. What was your experience with working with community partners?
6. How do you plan on incorporating data activism into your everyday life after the program ends, taking coding class, community?
7. How has your idea of data science in general changed? Was coding "intimidating" and if so is it still "intimidating"?

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