Notice, Wonder, Feel, Act, and Reimagine as a Path Toward Social Justice in Data Science Education

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ABSTRACT: In this paper, we introduce Notice, Wonder, Feel, Act, and Reimagine (NWFAR) to promote social justice in data science (DS) education. NWFAR draws on intersectional feminist DS to scaffold critical perspectives towards systems of power and oppression and attend to students' experiences in designs for learning. NWFAR adds three practices that are typically not emphasized in learning designs for DS: feel—engaging emotions and the physical body; act—challenging, inspiring, or informing others towards change; and reimagine—envisioning how data, data methods, and data technologies could pursue different problems, solutions, and perspectives. We illustrate NWFAR through two design-based research projects from prior empirical work. Through these two examples, we demonstrate what thinking with NWFAR could look like in practice and highlight future possibilities for learning. We conclude with a discussion that focuses on the reimagining dimension, in which we highlight social-justice oriented theories.

Keywords: Data science education, Data feminism, Critical data literacies, Social justice

1. Introduction

A data-driven world implies the essentiality of data practices (We prefer data practices to "data literacy," because we recognize there is a history of racialized and discriminatory uses of the term "literacy" (Philip & Rubel, 2019) or to data skills, because we view learning data science as a process of participation in situated practices with tools (Gutiérrez & Rogoff, 2003).). Accordingly, an enthusiasm for data science (DS) education—that is, education that leverages computer science, statistics, and mathematics knowledge for learning data practices—now extends to K-12 schools (e.g., LaMar & Boaler, 2021). The preK-12 Guidelines for Assessment and Instruction in Statistics Education (GAISE II; Bargagliotti et al., 2020), for example, present "statistical literacy for all" as an "ultimate goal" (p. 5). However, stated goals like "statistical literacy for all" promote equity but with a generality that conceals structural inequities embedded within data practices that harm people from historically marginalized groups (Benjamin, 2019; Martin, 2003). Expanding access to data practices does not in and of itself respond to systemic inequities like racism or how the use of data might be a driver of injustice and oppression (Benjamin, 2019; Eubanks, 2018; Noble, 2018; O'Neil, 2016; Philip et al., 2013). Furthermore, the contemporary expansion of K-12 education to include DS, in terms of resources, technologies, and programs, rarely extends to education about how data and its uses could inspire or inform needed social change.

In this paper, we put forward a set of guiding questions to shape the design of learning environments for DS, focusing on learning environments that support students creating and/or interpreting data visualizations to inform decision-making and conclusions about real-world phenomena, with the goal of promoting social justice. We use Swalwell's (2013) conceptualization of social justice as one that:

> [R]ecognizes and affirms difference (e.g., cultural, sexual, political) while maintaining a commitment to fundamental human rights and democratic principles (e.g., freedom of speech and freedom of religion)...[C]hallenges the current distribution of resources in order to secure the basic needs required for human flourishing (e.g., safety, food, shelter, water, love)...[A]ssumes unequal power relationships and challenges the belief systems and social relations that (re)produce power differentials (p. 17, citing Nussbaum, 1992 and Fraser, 1997).

Social justice is an ongoing process, rather than an outcome, that must be continually sustained to attend to both material and ideological conditions that are always in flux. Further, we emphasize that this conceptualization of social justice does not locate sources of injustice within the minds and actions of biased individuals. Instead, a social justice orientation allows us to identify and challenge unequal power structures located in society at multiple scales.

We first discuss two current approaches to centering social justice in learning designs for DS. We then introduce and situate an instructional heuristic—Notice, Wonder, Feel, Act, and Reimagine (NWFAR; for earlier discussions of these ideas, see Rubel, 2020; Rubel et al., 2021a; Rubel et al., 2022)—in response to these approaches. We extend the "Notice and Wonder" instructional routine that originated with Burton (1984) by drawing on intersectional feminist perspectives on DS (D'Ignazio & Klein, 2020; Rubel et al., 2022). We then use NWFAR to reexamine two examples from previous empirical work from this authorship team. Finally, we point to scholarship outside of DS and statistics that offer new ideas for researchers and practitioners to work towards social justice goals.

2. Beyond humanistic and critical approaches to DS education

Existing guidelines for engaging students with data tend to emphasize technical skills and, beyond a few passing references to ethics, do not address its social uses and impacts. For example, GAISE II encourages educators to open opportunities for students to pose a question and then collect, interpret, and represent data towards answering their question (Bargagliotti et al., 2020). However, an approach to DS education that merely encompasses technical skills "leaves hardly any room for ethical and political considerations" (Bhargava et al., 2020), "disregards the need to address deeper structural issues of inequality" (Fotopoulou, 2021, p. 1641), and does not help students critique data, data practices, or the contexts in which data carry meaning (Philip et al., 2016). In the absence of adequate ethical and political considerations, individuals and institutions will continue to use data to support practices of oppression through technologies such as facial recognition software (Benjamin, 2019; Buolamwini & Gebru, 2018). For these reasons, it is imperative that educators promote the technical aspects of data practices alongside knowledge of and a desire to act with respect to issues of social justice and broader sociopolitical and cultural concerns related to data and data practices (Fotopoulou, 2021; Lee et al., 2021; Philip et al., 2016; Wilkerson & Polman, 2020; Stornaiuolo, 2020).

Two interrelated strands of research engage data practices with understandings of broader sociopolitical, cultural, and ethical concerns, the first of which takes a "humanistic stance" toward DS (Lee et al., 2021), while the second promotes "critical data literacies" (Tygel & Kirsch, 2016; Stornaiuolo, 2020; Fotopoulou, 2021). Lee et al. (2021) call for a humanistic stance that recognizes that data practices comprise intersecting personal, cultural, and sociopolitical layers that shape learners' experiences with data. They describe a humanistic stance as one that attends to students' personal and direct experiences with data, the cultural and sociotechnical infrastructures of data collection and use, and broader political and social narratives that affect data practices (We understand Lee et al.'s (2021) use of humanistic as different from "humanizing," such as in Paris & Winn's (2013) humanizing research, del Carmen Salazar's (2013) humanizing pedagogy, or Gutiérrez's (2018) rehumanizing mathematics, in how the latter uses of the term emphasize decolonization.). Lee at al. (2021) propose this broad humanistic stance as a starting place for more research and more specific frameworks that could support "critical participation" in data practices (p. 7), including the technical practices (i.e., generation of data, interpretation, argumentation) and considerations of how data is situated within systems of "power and privilege" (p. 4) typically associated with critical data literacies.

The strand of research that promotes critical data literacies often draws inspiration from Freire (1993). Tygel and Kirsch (2016), for example, frame critical data literacies in terms of reading, communicating, and producing data—all toward emancipatory goals. Others add considerations of when and where data are collected, how data are manipulated by hidden algorithms, and how ethics impact data practices, including concerns about privacy and the skewed incentive structures created by data practices (D'Ignazio & Bhargava, 2015; Hautea et al., 2017). Philip et al. (2016) argue that data practices must occur alongside deep interrogations of race and power, without which opportunities to learn about data can become counterproductive for failing to address connections between data practices and white supremacy. Stornaiuolo (2020) suggests that key objectives of critical data literacies include the opportunities for students to see themselves as agentic producers of data, to exploit data for their personal purposes, and to understand that data are "socially situated resources for meaning making" (p. 81; see also Pangrazio & Selwyn, 2019). Common themes across this body of work include the integration of technical data practices with sociopolitical awareness of power and identity as well as an orientation towards emancipation.

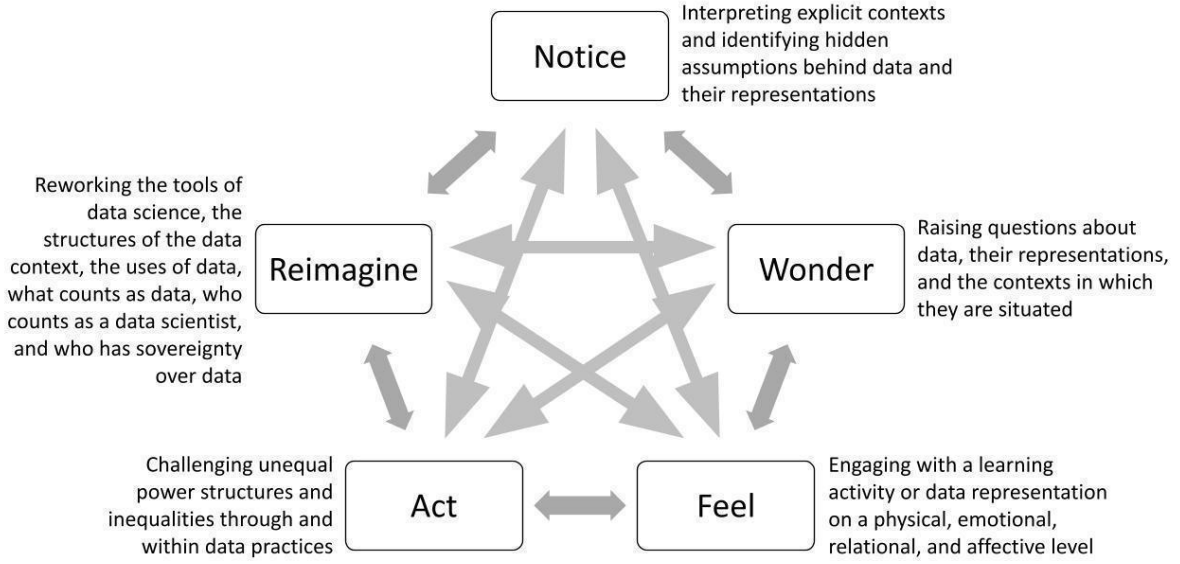
Common to both a humanistic stance toward DS and a critical data literacies approach is a focus on individual students' experiences with data, their agentic responses to data, and their capacities to intellectualize data and data practices with personal, technical, cultural, and sociopolitical lenses. Consequently, these perspectives may seem to overly emphasize the role of individual cognitive resources and rational responses to the way we experience the world (Bondi, 2005). That is, these perspectives treat rational processes of human decision-

making and sensemaking as the primary objects of teaching and learning about data. However, as intersectional feminist scholars (e.g., D'Ignazio & Klein, 2020) and others interested in affect theories (e.g., Bondi, 2005) argue, aspects of engaging with the world, including aspects of our engagements with data and data practices in service of social justice, lie beyond the realm of rationalist explanation and sensemaking. These non-conscious and non-individual processes include feelings, as well as affective dimensions of social action and imagination, all of which are situated within relations of power among human and non-human individuals and collectives (D'Ignazio & Klein, 2020; Van Wijnendaele, 2011). Even justice-oriented researchers tend to privilege thinking and discourse over emotional, felt, and non-conscious experience as the primary means of acting with respect to social justice goals (Van Wijnendaele, 2011). In alignment with these critiques, we elevate feeling, action, and reimagination with thinking and discourse as data practices important to the process of social justice. Our proposed instructional heuristic, NWFAR, could be integrated into critical data literacies or humanistic approaches to DS. On one hand, to support critical data literacies, NWFAR encourages participation in analytic reasoning about data and its personal, cultural, and sociopolitical contexts. On the other hand, NWFAR also prompts teachers and students to engage with data affectively, by positioning feelings, actions, and the imagination as central aspects of DS education rather than peripheral ones, and to reflect on systems of power explicitly.

3. Notice, Wonder, Feel, Act, and Reimagine (NWFAR)

NWFAR functions as a kind of reflection tool for thinking about designs for learning from an intersectional feminist perspective. Such questions can inspire or influence new learning designs, for example, in the form of new or revised curricular materials, approaches to teaching, or forms of assessment, that consider issues of emotion, praxis, and the imagination, which are not captured by popular strategies such as the Notice and Wonder routine in use (Burton, 1984; Fetter, 2015; Gonchar & Schulten, 2017; National Council of Teachers of Mathematics, 2021). The "Notice and Wonder" routine begins when a teacher presents a data visualization and asks students "What do you notice?" and "What do you wonder?" The routine has multiple purposes, including facilitating participation, encouraging student sense-making, and communicating that there may be more than one correct answer to a problem. GAISE II, for instance, uses the language of noticing and wondering to prompt students to make observations about data (e.g., patterns or features of graphical displays, like axes or measures) and ask questions about the data pipeline (e.g., how, why, and for whom data were collected; Bargagliotti et al., 2020). NWFAR makes use of the instructional efficacy and popularity of Notice and Wonder in ways that foreground social justice.

Figure 1. Notice, Wonder, Feel, Act, Reimagine



NWFAR revises the "Notice and Wonder" routine in two ways. First, NWFAR reworks the notions of *notice* and *wonder* to be more closely tied to goals of social justice, rather than their original purposes of prompting questions for mathematical sensemaking. Second, NWFAR creates opportunities for learners to *feel*, *act*, and *reimagine* as responses to data and data practices, in addition to noticing and wondering. We draw on D'Ignazio and Klein's (2020) data feminism in developing these revisions. Data feminism is an intersectional feminist perspective that offers an alternative to the "male and white and technoheroic" paradigm of DS (D'Ignazio &

Klein, 2020, p. 9; see D'Ignazio & Klein (2020) for examples and elaborated discussion; Lunn et al., 2021), counters the prevalence of racism and sexism through DS, and calls for broader engagement of activists and community organizers in DS (e.g., Data for Black Lives, n.d.).

Our proposal of NWFAR is not intended to be a routine in the way that Notice and Wonder has been adopted among many mathematics educators, as a clearly defined ritual (see Rumack & Huinker, 2019). NWFAR is not a step-by-step approach to prompt students to recognize what they notice, wonder, feel, act, and reimagine in a particular order. Instead, it is a collection of possible starting points that can be approached and revisited in any sequence (Figure 1). In the following sections, we briefly expand on each of the elements of NWFAR and provide guiding questions for each dimension.

3.1. Notice

Notice refers to interpreting elements of the data visualization itself. These elements can include data sources, data trends, relationships between variables, comparisons between data points, identification of outliers as well as visual elements including titles, labels, annotations, or authorship information. Notice also refers to observing what is absent or left out. Questions that promote practices related to noticing but often are overlooked in typical curricular uses of notice include: (1) Whose perspectives are represented and whose are ignored? (2) How, when, and where was the data produced and by whom? (3) How does the visualization account for race, gender, class, and place and their intersection? (4) How do the authors describe the purpose of this visualization?

3.2. Wonder

Wonder means posing questions that are not directly answerable. Wonder raises questions about the data (and data that are missing), the process of producing and communicating data, and the contexts in which data are produced, for which there is no direct evidence in the data visualization. Questions that extend conventional prompts of "What do you wonder?" include: (1) What might the data visualization look like if it (more explicitly) acknowledged how race, gender, class, and place (and their intersections) play a role in the data context? (2) Who might benefit from the represented point of view, and who might profit from this dataset? (3) What might the data visualization look like if it more explicitly attended to human and non-human stakeholders and their physical bodies? (4) What might be some of the assumptions that the designers of the data visualization and activity make about people and relationships? (5) Who might have been involved in the collection, production, interpretation, analysis, visualization, and communication of the visualization?

3.3. Feel

Feel represents practices of engaging with a learning activity or data visualization on a physical, emotional, relational, and affective level. Embracing emotion represents an act of resistance against dominant practices in DS that tend to code reason as masculine and emotion as feminine and thus elevate reason but cast suspicion on emotion. Embracing emotion allows us to let go of the binary logic between reason and emotion and allow both to inspire action toward justice (D'Ignazio & Klein, 2020; e.g., hand-drawn data illustrations by Chalabi (Rakotondravony, 2019)). Through an emphasis on feeling, we follow the "affective turn" in feminist theory to challenge the notion of universal objectivity as a privileged goal when engaging with data (D'Ignazio & Klein, 2020; Pedwell & Whitehead, 2012). Data practices can and should include visceral experiences that involve the body, physically and emotionally (Malinverni & Pares, 2014). This includes engaging the body through senses such as touch and the feelings that these senses generate (Lupton, 2017), through embodied practices such as gestures and movement to interact with and represent data (Roberts & Lyons, 2019), and through emotions (Kennedy & Hill, 2018). Questions include: (1) How does this data visualization engage your body, your senses, and your emotions? (2) How might this visualization make space for multiple kinds of feelings? (3) How does the data or context connect to interpersonal relationships or to relationships with nonhuman others and the planet?

3.4. Act

Act refers to challenging unequal power structures and exposing inequalities through and within data practices. D'Ignazio and Klein (2020) offer examples for what acting can look like in DS: compiling counterdata, challenging power by analyzing inequitable outcomes across different groups, working towards co-liberation,

and cultivating a new generation of data feminists. As we argued in earlier work (Rubel et al., 2021b), action directed toward transforming systems of power must go beyond merely "playing the game" of DS. Instead, the act dimension of NWFAR must also include seeking to "change the game" through critique and social action (Rubel et al., 2021b; see Gutiérrez, 2011). Questions include: (1) How can you use the data or data visualization to challenge and inform, inspire, or support political action? (2) How does this data visualization raise ethical questions, including questions about data security and data privacy? (3) What might you learn from reaching out to others about information presented in this data visualization? (4) In what ways are you moved to act, to refrain from action, to make change, or to communicate to others?

3.5. Reimagine

Reimagine describes practices directed toward reworking DS tools, as well as the structures of the data context, its uses, what counts as data, who counts as a data scientist, and who has sovereignty over data. For instance, reimagining could entail thinking about how a data visualization could produce a different solution or show different perspectives. This use of reimagination draws on the data feminism principle of elevating emotion and embodiment in DS (D'Ignazio & Klein, 2020; Ioannou & Ioannou, 2020) by challenging (e.g., artist Onuoha's (2016) Library of Missing Datasets calling attention to the absence of data) and reinventing existing data visualizations and data stories. For example, the Data Zetu program in Tanzania created a fashion competition and show in which fashion designers reimagined how open public health data could be used by designing clothing for women that could spark conversations around sexual and reproductive health and sexual and gender-based violence (Katuli, 2018).

Warren (2021) offers a way of thinking about reimagining, drawing on Kelley's (2002) *Freedom Dreams: The Black Radical Imagination*. Warren's framework for centering possibility in Black education comprises nine interlinked concepts: Resistance, Dreaming, Storytelling, Creativity, Thriving, Community, Reparations, Environment, and Teaching. We expand on resistance (what needs to be torn down) and dreaming ("what should be built atop the rubble," p. 31) because of their importance in Warren's teachings about a future-oriented Black education transformation and their potential for developing designs that make reimagining a more central aspect of learning with data. Resistance "encompasses multiple forms of opposition to education conditions, broadly conceived, that insist on Black folks' subordination to Eurocentric expectations for thinking, speaking, and being" (Warren, 2021, p. 21). Resistance requires critical reflection on how schooling, and, for purposes of this paper, data and their contexts, necessitate opposition to unjust authority figures and systems. Dreaming provides a means for reimagining the capabilities of Black (and other marginalized) individuals to "produce novel creations that respond to or solve a problem of interest to the maker: designs guided primarily by the desire of the producer versus that of the colonizers" (Warren, 2021, p. 36). Warren's articulation of resistance, dreaming, and creativity link to the kinds of speculative fiction, science fiction storytelling, counter-storytelling, and allegorical storytelling that have begun to appear in STEM education work. In the discussion following our example analysis, we point to theoretical perspectives that offer more radical approaches to reimagining that could move DS education further towards social justice and equity goals.

4. Returning to prior work to illustrate and extend NWFAR

In this section, we revisit prior work from among this authorship team using NWFAR. Both projects prompted youth to explore questions about socioeconomic issues that resonated with their personal, family, or community experiences through activities that included exploring georeferenced, large-scale datasets and digital data visualization interfaces. The first example, the Lottery Project, was a design-based project, in collaboration with a mathematics teacher, that engaged high school students in investigating the role and impact of the lottery on the local community (Rubel et al., 2016a; Rubel et al., 2016b; Rubel et al., 2017). After learning how to calculate the probability of winning various lottery games, the students collected data about people's experiences with the lottery and analyzed lottery spending across neighborhoods. The second example, the Family Migration Project, comes from a design-based research study that asked teenage youth to investigate personal family migration histories with data in a summer program (Kahn, 2020). Students explored family histories and experiences with family members and connected those to analyses of socioeconomic data trends to tell the stories of what moved their families.

We use NWFAR as a tool to analyze the intended and enacted designs. More specifically, we point to the projects to demonstrate the feeling and acting components of NWFAR. We look across these two examples to identify learning opportunities that could have been supported if one were to redesign with NWFAR in mind. We

show that our examples of reimagining are limited; when prompted, students' reimagining stayed within existing structures or systems. In our discussion, we point to possible directions for future iterations of NWFAR.

4.1. Feeling and acting in the Lottery Project

The Lottery Project is a curricular unit engaging high-school students to learn about the lottery as a public system and its impact on their community (Rubel et al., 2016a; Rubel et al., 2016b; Rubel et al., 2017). Students learn about the lottery by calculating the probability of winning local lottery games, analyzing ticket sales data across their city, and noting how the state utilizes lottery revenue. They learn about the impact of the lottery in their community by interviewing people about their lottery participation and mapping where lottery tickets are sold. In retrospectively revisiting the learning designs for the Lottery Project using NWFAR, we identify attempts in the design to engage students to feel by drawing on their own and their community members' lived experiences to inform critical analyses of the lottery system and prompt students to act and reimagine in response. All descriptions below are based on field notes and artifacts from classroom observations conducted in a high-school class in a large city in the Northeastern United States. Artifacts included photographs of student work and of the classroom whiteboard.

Various activities in the Lottery Project prompted students to feel. For example, a lesson early in the unit asked students to contribute their free associations with the lottery to create a collective Word Wall. The open prompt engaged students' personal reactions. Through the Word Wall activity, we learned that some students sensed that the lottery is unfair, for example, with some expressing their chagrin that "Black people don't win." These collective ideas would factor into students' stance toward questioning the lottery system. Through the project, there were reflection opportunities, in which students could express other feelings. Examples of expressions of feeling included surprise about the slim chances of winning and that this system is predesigned and owned by the state; outrage about the lottery operating as a "scam" targeting low-income areas; resignation about the lottery operating under the notion of free choice; and promise about the lottery providing hope and funding for education.

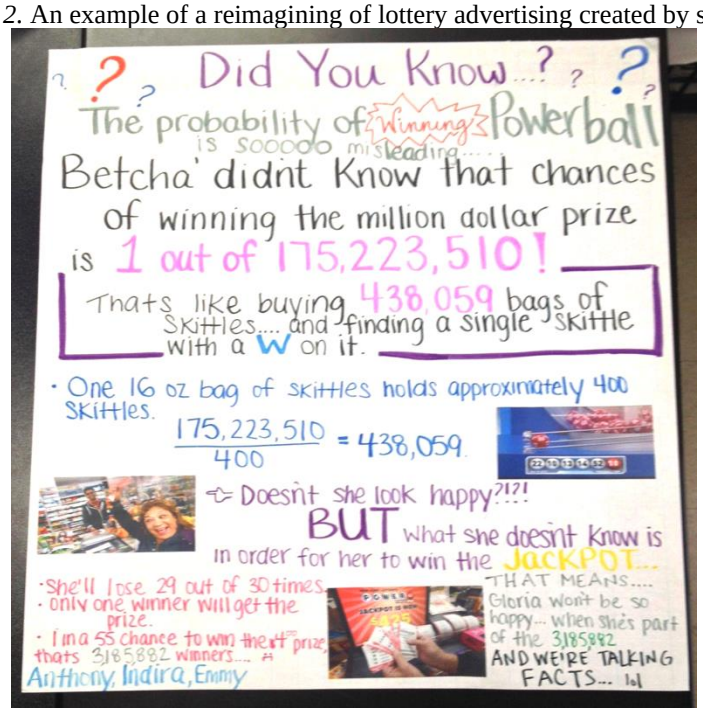
The Lottery Project included a field research component, in which students extended their inquiry into the lottery's presence and impact into the local neighborhood. This field research engaged participants' physical bodies by their interaction with people, places, and their physical environments. By interviewing people in the neighborhood, students could supplement their own experiences and add complexity to the personal stories about the relationships that people have to the lottery. For example, in a class debrief of their findings from these interviews, students noted that some people buy lottery tickets out of an addiction, but many view the lottery as a chance to satisfy basic needs and change their lives—paying children's college tuition, providing housing for family members, or returning to their home countries. The field research enabled students to consider personal and emotional elements in their understanding of the lottery alongside learning about the low probability of winning these lottery games. They learned that playing the lottery is not necessarily indicative of poor mathematical decision-making but rather an almost guaranteed outcome of an institution that is designed to prey on the most vulnerable people.

The project's technology enabled multilayered analyses of qualitative information about peoples' experiences in context and quantitative data about lottery spending and revenues. Students explored interactive maps showing daily lottery spending, median household income, and the ratio between these two figures by neighborhood. The lessons guided students to make comparisons among neighborhoods and notice and wonder about how the ratio of lottery spending to income is higher in lower-income neighborhoods. These interactive data visualizations, created by the research team, were the base layers for embodied, qualitative data that the students gathered. That is, students captured audio recordings, photos, and text from neighborhood interviews and uploaded these data as geolocated objects. Thus, students connected and grounded their analyses of the city-scale quantitative data to the local-scale and vice-versa. As a result, students had the opportunity to notice, wonder, and feel the lottery's impact in a more nuanced way.

The project also created opportunities for acting and reimagining. For example, using combinatorics to calculate the miniscule (yet hidden) probability of winning various state lottery games, students created posters to speak back to the state's "Hey, You Never Know" advertising campaign. Through these "Hey, Now You Know" posters, students reimagined the public lottery messaging into educative forms. For example, a group of students likened the chances of winning the Powerball game to finding a single, marked Skittle among 438,059 bags of skittles (Figure 2). The students included a photo of a gleeful-looking woman posing with lottery tickets in hand, captioned, "Doesn't she look happy?!?!" followed by a "BUT" and a list of caveats based on probability calculations, concluding that "Gloria won't be so happy" when she realizes she is part of the large number of

losers. A second set of activities prompted students to reimagine the lottery as a system. As this played out, students primarily considered how the lottery could be redesigned to produce more winners from their community. Students were hesitant, despite guidance, to fundamentally reimagine the lottery system, as a source of public funding, private income, state revenue, or as a way for people to change their lives. We interpret this hesitation as shaped by how infrequently social justice is engaged in education as a matter of reimagining basic systems that are indeed transformable.

Figure 2. An example of a reimagining of lottery advertising created by students



4.2. Feeling and acting in the Family Migration Project

A second project (Kahn, 2020) offers an example that moved beyond the traditional notice and wonder pedagogy by centering family relationships and conversations as a starting point for data exploration. In this project, students (n = 17, mostly African American, ages 11-16) participated in a free summer program at a public library in a midsized southern city. Students connected their family migration histories (where they live, where they moved to), or *family geobiographies*, to the socioeconomic push and pull factors that drive family migration through an exploration of demographic datasets using two data visualization tools (Social Explorer, Gapminder). All descriptions below were based on interaction analysis of video and audio records of activities, including screen capture recordings of data exploration on laptops, as well as fieldnotes and students' final PowerPoint family data stories.

By starting with a retrospective, personal inquiry, we created spaces for the NWFAR dimensions of feeling and acting by providing an opportunity for families to be involved in learning. The Family Migration project began by asking students to trace their family geobiography back to their grandparents' generation. The family geobiography positioned the perspective of families at the center of the exploration of the aggregate data. During the workshop, the project leveraged students' relationships with siblings also participating in the workshop and other family members. Students were encouraged to text or call parents or relatives during the sessions and talk with their family on the intervening nights between workshop days. Family members consequently participated in the assembling of data stories, and students worked to resolve and/or represent multiple voices and stakeholders. This distributed effort (Kahn, 2020) challenged the traditional DS approach to human individuals as isolated data points. Similarly, in informal interviews at the end of the project, nearly all students said they would talk to family members to answer the questions that their projects raised. We view these conversations with family members, both those that occurred in the workshop and those intended for the future, as related to acting. The involvement of families and the telling of family histories also opened a space for feeling and emotion while engaging with the data.

The design incorporated traditional approaches to notice and wonder around interpreting data displays. We asked students to notice and wonder about aggregate-level trends in the data models and maps. However, we

consistently situated noticing and wondering practices in familial and personal contexts. For example, one of the first activities asked students to brainstorm (wonder) about what moved families in general and then explore those factors with variables using the data tools. Students looked for differences across places (where their family member lived previously compared to where they moved to) on variables like income and education. Variables were sometimes selected by students on their own, other times suggested by instructors. Once students selected variables, instructors encouraged them to describe visual trends in the data. The interactivity of the data visualization web-based tools and the breadth of available data sets supported both practices.

The personal nature of noticing and wondering supported enactments of feeling and acting. For example, students frequently noticed that data that represented their family members' experiences was unavailable or that the data did not align with the story they wanted to tell. In turn, they pursued different strategies, such as the inclusion of multiple data displays in their data stories, to resolve this trouble in the data modeling environments (Jiang & Kahn, 2020). Steps to address the conflict could also be viewed as a form of acting with the data tools.

However, sometimes feelings clashed with noticing and wondering. For example, several students wanted to pursue stories about why their family moved for which they could not find a related dataset. For instance, one student wanted to tell the story of how her mother moved from Thailand to the United States for love—to marry her father. Love, however, is a variable that does not exist in traditional demographic datasets. Another student wanted to tell a data story about her family's celebration of Kwanzaa but similarly could not find an appropriate demographic variable to represent the population that celebrates this holiday. In future iterations, these conflicts between family stories and the limitation of datasets could be leveraged as opportunities for reimagining the data and data visualization.

The project incorporated several embodied data activities as well that were intended to serve as resources for reasoning about historical socioeconomic conditions from a relational perspective and with affect, although these were outside of the data visualization environment (as opposed to the exploration of data displays driven by body movements as in Roberts & Lyons, 2020). Students performed a walking-scale timeline that asked them to stand in for the family in historical time; we repeated this embodied activity with parents and students at the culminating public showing of student work. In all sessions, we also asked students to participate in a four walls game (like a four corners game). When asking the students to select a family member, we were also asking them to physically stand in and speak for their family members, who potentially had survived or witnessed discrimination and prejudice. For instance, questions about occupations raised additional queries like what constitutes "work," particularly for students thinking of enslaved ancestors, with some students stating that any forced labor under slavery should not qualify as an occupation. We also wanted students to be able to assemble stories or models grounded in experiences of people of color and challenge dominant social ideologies of equality and opportunity if they wanted to tell these stories. We found that students recognized their families' struggles in their data stories but focused on the positive outcomes for their family members. Being in charge of their own stories, including what data to show, was powerful for students.

Finally, students were not asked to reimagine the data or data tools in this project. In this way, the use of existing data visualization platforms and datasets arguably restricted the enactment of this part of NWFAR. However, our design did have students' futures in mind (e.g., we asked students where they see themselves living when they grow up). Additionally, some students considered what their lives might have been like if their family had not moved and assembled data stories around this reimagination of their own lives (a hypothetical counterfactual; Kahn, 2020). Below we discuss other possibilities for reimagination.

5. Discussion

NWFAR draws on intersectional feminism to examine power and promote equity within DS. The values and ethics embedded in this instructional heuristic depart from existing approaches to DS education. DS tends to be a white male space that emphasizes individuality, competitiveness, and the development of technical and cognitive skills but leaves out other ways of knowing and being. With NWFAR, we seek to add a new perspective to the growing body of scholarship committed to countering the creation and perpetuation of harmful and discriminatory data-driven practices that contribute to the marginalization of women, people of color, and other historically marginalized groups.

Our reflections on two projects supported the development of NWFAR. The two projects are examples that illustrate how learning designs can make space for feelings, both physically and emotionally, and motivate or inspire action in ways that are productive for developing critical perspectives towards issues of power, equity,

and social justice. Both examples implemented notice and wonder in ways that attended to personal or local community histories and experiences and emphasized feelings and emotions in data engagements. Students were guided to act in various ways, such as creating posters as part of a public messaging campaign and having conversations with family members about their geobiographical histories.

There were moments in these projects when students engaged in practices of reimagining, but broader reworkings of the tools, structures, and uses of DS were not incorporated into the designs. Students were asked to reimagine public messages around the lottery (e.g., *Hey, Now You Know* posters) or reimagine the lottery system itself. In the family migration project, some explored what their lives would have been like if their families had a different geobiographical story. There is ample room to deepen how we might engage students in reimagining. In the Lottery Project, for example, we could have asked students to generate ideas for creating alternative opportunities for investment that would directly benefit their own communities. More fundamentally, we could have prompted students to consider what it would take for society to ensure that no one could be vulnerable to relying on the lottery for basic needs and resources. In the family migration project, we could have asked students to reimagine data that included their family members' experiences or to develop their own alternative history narratives, incorporating details about how their lives and the lives of their families and communities might have shaped and been shaped by broader sociopolitical and historical forces. In this way, reimagining becomes a way to use ideas about desirable futures and alternative pasts as tools to aid in speculative thought about how life could or should be in the present. Thus, reimagining practices seek to center justice, dignity, and freedom, especially for marginalized peoples and communities.

Additionally, our projects used public DS resources (open data visualization applications) as pedagogical tools to foster students' data practices. However, the use of professional data technologies in instructional settings raises questions for how to design and use these resources to support critical data practices as well as relational, affective learning experiences. In our project examples, to accomplish this, we intentionally connected activities outside the data interfaces that generated qualitative data (e.g., brainstorms, field research, walking-scale timelines) to data visualizations. Alternatively, there are other possibilities for achieving the goals of NWFAR within the technologies themselves. For example, while new DSE research has looked at developing tools for students to build machine learning models with data to gain a fundamental understanding of artificial intelligence (AI; e.g., Biehler & Fleischer, 2021), the activity and AI interface could be designed to help students learn the subjectivity of model development and decisions made by AI, and how AI can perpetuate biases and unfairness. Both data technologies and the learning experiences created around them should be redesigned to support complex reasoning about data to help students to engage with issues related to power, equity, and social justice.

5.1. Future directions: Developing "reimagine" in NWFAR

The act of reimagining—oneself, one's community, and one's society—is a powerful but often overlooked data practice. As we have reflected, the projects could have more deeply engaged students in practices of reimagining to better support social justice and equity. In line with how data feminism relies on broad and diverse examples and intellectual traditions, we turn to literature outside of DS education, including Black feminist thought and Indigenous quantitative methodologies. These theories draw on various frameworks and intellectual traditions, including critical Afropessimism (as opposed to vulgar Afropessimism, see Woodson, 2021), radical hope (Grant; 2021; Kelley, 2002), Black liberatory fantasy (Dumas & Ross, 2016), critical race theory (Crenshaw, 1991; Davis & Jett, 2019), BlackCrit (Dumas & Ross, 2016; Martin et al., 2019), Afrofuturisms (Alexander, 2019; Bell, 1992; McGee & White, 2021), Indigenous Futurisms (Dillon, 2012) and alternative histories (Carroll, 2020; Rick, 2021). The frameworks are necessarily interdisciplinary, allowing for new connections across identities and disciplines (McGee & White, 2021).

Speculative education critiques historical and inequitable schooling conditions and seeks to actively reimagine and create new possibilities for education (Mirra & Garcia, 2020). Mirra and Garcia (2020) worked with classroom communities across the United States, asking students to define their civic communities, engage in conversation with peers around a chosen civic topic, and imagine and represent potential civic futures. Their third design cycle included opportunities for students to craft origin stories for their own "civic superheroes" and explore how such superheroes could address issues they found to be pressing. Mirra and Garcia (2020) found that the processes of imagination did not come easily to youth or adults as efforts of imagination came up against the reality of clashing political ideologies among students. Thus, opportunities that include supporting students to craft speculative narratives based on real-world datasets likely need attention to how practices of imagination might confront entrenched political beliefs or dominant perspectives about the purposes and possibilities of data and data technologies.

We emphasize that reimagining could become an empty gesture without careful consideration of the contexts in which the research or design work is being done. We recognize that ideas about speculative education, Afro- and Indigenous futurisms, and radical hope, among others, need to be thoughtfully and deeply applied to not overlook oppressive histories and further damage or harm historically marginalized populations. Using these theoretical perspectives requires serious consideration of whiteness, white supremacy, antiBlackness and patriarchy while engaging with these liberatory ideas, a task that may be challenging as DS and technology design fields continue to be dominated by white men.

6. Conclusion

NWFAR encourages DS education researchers and practitioners to raise important questions about data and data visualizations and look for opportunities to explore emotion, praxis, and imagination. Our conceptualizations of noticing, wondering, feeling, acting, and reimagining seek to go beyond mere participation in or access to DS and move toward embracing new forms of engagement with data and data practices, including an emphasis on affect and the relationship between data and issues of power. In this sense, NWFAR is a heuristic that directs DS education towards social justice. The next steps are to implement and study NWFAR in various contexts, including learning designs for K-12 education and teacher education. This process will generate information about how to revise the heuristic and refine its set of reflective questions.

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