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Authoring Data Stories in a Media Makerspace: Adolescents Developing Critical Data Literacies

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This article centers sociocultural and sociopolitical considerations of how young people understand, represent, and use data by presenting findings from a social design research study about how students in a public urban high school authored “data stories” using personal data they curated, collected, and visualized. The study contributes to theoretical understandings of critical data literacies by considering the experiences and practices of adolescents enrolled in a required media arts class as they produced data visualizations drawn from their everyday lives. Findings center on two aspects of critical data literacies youth developed—understanding themselves as people capable of using data for multiple purposes and understanding data as socially situated resources for meaning-making. This study foregrounds the importance of positioning youth as authors and architects of data, making central youth perspectives in understanding the role of data in young people’s digitally connected lives and highlighting the importance of expanding what “counts” as data. It also suggests the importance of creating infrastructure to support the development of culturally relevant data practices that highlight the social, cultural, and political uses of data and its racialized dimensions.

Researchers and educators are increasingly concerned with how young people, nearly half of whom report being online “almost constantly” (Anderson & Jiang, 2018), navigate a “datafied” culture in which they create data traces from the moment they are born (van Dijck, 2014). To address inevitable challenges that arise from such data abundance, scholars have suggested that that young people need to learn multiple

ways of generating, interpreting, and visualizing data (see Lee & Wilkerson, 2018), especially “personal data” that individuals generate through everyday activity (Pangrazio & Selwyn, 2018). A number of researchers have looked toward schools to support youth in learning with and about data, particularly data they collect themselves (e.g., Lee, 2019) and that reflect their cultural, embodied, and lived experiences and knowledge (e.g., Ching, Stewart, Hagood, & Rashedi, 2016).

Such efforts to develop culturally responsive approaches (Lee, 2003) to incorporating various technologies of the self in schools (Ching & Wang, 2012) represent a critical direction for scholars interested in youth’s data literacy (see Pangrazio & Selwyn, 2018). While data literacy is often defined as the capacity of “individuals to access, interpret, critically assess, manage, handle and ethically use data” (Calzada Prado & Marzal, 2013, p. 126), such definitions foreground the individual skills, abilities, and technologies involved in working with data. More critical perspectives on data literacy are needed to challenge approaches that position data as objective and neutral measures of the social world rather than highlighting their situated, ideological, and racialized nature (see Philip, Olivares-Pasillas, & Rocha, 2016; cf. Dixon-Román, 2016). Furthermore, data are often collected *about* youth, with young people themselves only rarely considered as authors, architects, or interpreters of data (see Bhargava et al., 2015)—an area of urgent concern given the rising intensity of surveillance and violence focused on youth from vulnerable communities and marginalized identities (Garcia & Philip, 2018).

This paper reports on a study of high school students’ data literacy practices from the perspective of *critical data literacies* (e.g., Hautea, Dasgupta, & Hill, 2017; Tygel & Kirsch, 2015), a framework that emphasizes the importance of youth perspectives about data and foregrounds issues of race and power (Philip, Schuler-Brown, & Way, 2013). Such framing challenges the positioning of young people in urban schools as objects (not agents) of data collection, particularly young people of color who are subject to deficitized or racialized interpretations of data that position them as “at risk” (Gadsden, Davis, & Artiles, 2009). This paper centers these sociocultural and sociopolitical considerations of how young people understand, generate, represent, and use data for multiple purposes by presenting findings from one semester of a broader social design research study (Gutiérrez, 2016) in an urban public high school. Focused on one data unit in the students’ media arts makerspace, this study sought to develop theoretical understandings of critical data literacies by exploring how 31 adolescents collected, interpreted, and visualized personally meaningful data, authoring “data stories” (Segel & Heer, 2010) from their everyday lives.

This study contributes to theorizing about critical data literacies and foregrounds the importance of positioning youth as authors and architects of data in such theorizing—that is, as agents of data collection and analysis rather than

objects of it. Such efforts make central youth perspectives in understanding the role of data in young people's digitally connected lives, highlighting especially the importance of expanding what "counts" as data to include personal narratives, art, and everyday activities. This study also points to the need to understand how personally relevant curriculum might support critical perspectives about data, particularly students' counternarrative work that can challenge and unsettle mainstream, deficitized, and racialized "data stories" about young people of color in urban schools (see Norris, 2014).

SITUATING DATA LITERACY IN YOUTH LIVES

In an age characterized by exponential growth and availability of data, research into how young people engage with data has focused on the importance of students learning to use them for personal, work, and civic purposes—to reason, construct arguments, make decisions, and assert control over their digital traces (e.g., Lee & Wilkerson, 2018; Radinsky, 2008; Rubel, Lim, Hall-Wieckert, & Sullivan, 2016). Researchers have been increasingly interested in how youth engage in these "personal informatics" (Li, Dey, & Forlizzi, 2010), including how people understand and represent the quantified self (Choe, Lee, & Schraefel, 2015) and navigate personal data literacies (Pangrazio & Selwyn, 2018). Lee (2019) has explored not just how students' thinking and behaviors may shift when they learn about data through their use of activity trackers and other wearable devices but also the sociotechnical arrangements that these new practices entail (see also Ching et al., 2016). Acker and Bowler (2018) and Bowler, Acker, Jeng, and Chi (2017) studied how teens in public libraries in Pittsburgh conceived of data in relation to networked and mobile technologies, finding that young people proffered various explanations of data's role in their lives but did not regularly reflect on issues of data privacy, surveillance, and ownership—nor did they necessarily see themselves as data producers. These findings suggest that education about data literacy can help youth critically reflect on data use and see themselves as people with data rights.

Despite a clear need for data science education to support students' thinking with/about data (Lee & Wilkerson, 2018), the uptake in K-12 settings has been minimal, with challenges ranging from the cross-disciplinary nature of data science to educator capacity (Finzer, 2013). In response, scholars are studying how young people develop data literacy across different learning contexts (e.g., Acker & Bowler, 2018; Rubel et al., 2016), theorizing the concept beyond a list of technical skills and abilities to include making meaning with data for personal, civic, esthetic, and emancipatory purposes (Bhargava et al., 2015), developing data habits of mind (Finzer, 2013), and marshaling data for counternarrative work that challenges unjust systems and structures (Philip et al., 2016).

The rising importance of data visualizations for such meaning-making work (e.g., Choe et al., 2015; Radinsky, 2008; Segel & Heer, 2010) highlights especially forcefully the *literacy* dimensions of data literacy. This article concentrates on these elements of the construct, especially students' productive work with data visualizations. Extensive research has examined student-generated representations as tools for content learning, with Gebre and Polman (2016) studying students' "representational competence," and particularly their capacities for visual thinking at abstract levels. This productive focus on students' representational practices with their own data complements and extends work on students' interpretive efforts to make sense of complex sets of visual data, such as students' analyses of existing visualizations (e.g., Philip et al., 2016) or their reasoning with dynamic spatial data (e.g., Rubel et al., 2016; cf. Taylor, 2017). Scholarship about the productive dimensions of students' representational practices has examined how makerspaces, as places for hands-on engagement with material and digital tools, can be supportive for developing youth's critical capacities as producers of meaning, their identities as "makers," and the esthetic dimensions of youth's representational practices (e.g., Norris, 2014; Tan & Calabrese Barton, 2018).

In considering how to design learning environments to foster data literacy, scholars have raised questions about how students are positioned as data producers and analysts, particularly in secondary school classrooms and for young people of color. Radinsky (2008), for example, examined how middle schoolers working with GIS visualizations took up temporary roles as people who could make sense of visualized data to varying degrees; such role construction, Radinsky argues, operates as an important site of science learning. Social positioning, as Holland and Leander (2004) explain, involves the ways people and groups are ascribed, take up, negotiate, and contest different roles or positions ("troubled youth," "girl"), representing a primary way of forming subjects and subjectivities. Philip et al. (2016) examined issues of social positioning in relation to data literacy, investigating how students of color were positioned in racialized ways in a classroom discussion about data; the study traced how two students challenged racialized interpretations of a data visualization through racial-ideological micro-contestations. In calling for schools to create curriculum and teacher development around racial data literacy, the authors foreground "the everyday sense-making of youth of color in their experiential knowledge" (p. 384).

Like Philip et al. (2016), several studies suggest that inquiries grounded in youth's everyday lives can support the development of culturally attuned data literacies (e.g., Taylor & Hall, 2013). Rubel et al. (2016), for example, worked with students in an urban high school to develop spatial reasoning in a remedial mathematics class, using digital GIS maps and other data to understand the

impact of the lottery on neighborhood communities. While students felt they could bring their perspectives and experiences to bear in meaningful inquiry, they resisted how the curriculum positioned them and communities of color in deficitized ways. These findings indicate the importance of co-constructing curricula with students, taking into account their beliefs about data as well as the racialized and gendered positionings they experience, and actively working against curriculum that essentializes students' experiences or assumes what they find meaningful or relevant.

Recent studies confirm the challenges of designing culturally relevant pedagogies that build on students' knowledge and perspectives (Lee, 2003). In their study of sixth graders learning about math statistics through free-choice inquiry projects using census data and GIS maps, Enyedy, Danish, and Fields (2011) found that students constructed their own meanings of relevance through intense negotiation between themselves, the curriculum, and the teacher. They suggest that educators focus on supporting students in negotiating relevance, a process through which youth can draw on local knowledge and cultural practices. Kafai, Searle, Martinez, and Brayboy (2014) similarly worked to design culturally responsive learning opportunities with Native American youth learning to use e-textiles. They found that youth designed projects that drew on popular culture and personal interests but not their community funds of knowledge or indigenous cultures, suggesting that students may need additional time or support to be comfortable bringing in local cultural knowledge.

One direction scholars have turned to support this work toward culturally relevant data pedagogies is critical data literacies. In developing this concept through a study of youth in a Scratch online community using data for programming, Hautea et al. (2017) suggest that a critical perspective involves foregrounding youth perspectives and questioning power structures, an approach rooted in Freire's work (2003) on emancipatory efforts to understand and express oneself in the world (cf. Tygel & Kirsch, 2015). Perhaps the most instructive approach for developing a theory of critical data literacies for youth is Philip et al.'s (2013) data framework for democratic participation. By grounding their framework in equity and social justice and framing it in socio-cultural approaches to learning (e.g., Nasir & Hand, 2006), Philip and colleagues present data as a powerful means to address social issues and disrupt inequities. They argue that to engage with data for such purposes, youth need to "see themselves as doers and creators of data science, people who can engage with and use data for their own purposes and goals" (pp. 114–115). Such an approach invites an understanding of data not as invested with "true" and "objective" meanings, but as assemblages that are spatially and temporally constructed and laden with assumptions, ideologies, and histories (Dixon-Román, 2016)—that individuals can create and use toward their own ends.

Scholarship about designing learning environments oriented to equity and critical justice have highlighted the potential of makerspaces to forward such critical data literacy capacities (e.g., Castek, Schira Hagerman, & Woodard, 2019; Tan & Calabrese Barton, 2018; Tucker-Raymond & Gravel, 2019).

METHODS

This study was organized as a social design experiment (Gutiérrez, 2016) in the context of a longitudinal partnership between the author and a public urban high school on the East Coast, the Collaborative Design School (CDS; all names are pseudonyms). The partnership began with the 2014 opening of this “innovation” school and focused on studying the development of several interdisciplinary makerspaces over the school’s first 5 years. This study, conducted during the 2017–2018 school year (the school’s fourth), took place in CDS’s media makerspace in collaboration with the media arts teacher, a longtime district teacher with experience teaching a variety of humanities, arts, and science classes.

This study takes up Gutiérrez’s (2016) call for designing consequential educational interventions that radically shift views of learning, foreground perspectives of youth from nondominant communities, and aim to create local and institutional change. Like design-based research methodologies, social design research similarly engages in evidence-based theory building through iteration, attention to context, and partnership with stakeholders but is centrally premised on design principles of equity and historicity (Gutiérrez & Jurow, 2016). Such an approach to designing theoretical and practical educational interventions seeks to expand learning by reorganizing the sociohistorical practices within communities to create more equitable and just outcomes for learners.

In the broader social design study in which this paper is situated, school stakeholders and researchers worked over the course of several years to reorganize learning by integrating project-based, hands-on, inquiry-oriented, and culturally relevant curricula in the school’s makerspaces. By linking these makerspaces with communities and content courses in the school, the goal of the broader study involved positioning youth from nondominant communities as makers, designers, and authors of their own futures. Such a focus on the equity dimensions of making, particularly for and with working-class students and youth of color who are not often recognized as “makers” (see Vossoughi, Hooper, & Escudé, 2016), builds on youth’s everyday practices and interests and links those historicized practices to issues of educational equity.

In this data project over the 2017–2018 school year, the media arts teacher and I collaborated to design an educational intervention that framed data as situated, ideological, and racialized, positioning youth as authors, architects, and interpreters of their own data stories; such efforts were located within broader

structures of power and oppression that demanded heightened reflexivity on our part (Vakil, McKinney de Royston, Nasir, & Kirshner, 2016). Building on students' interests in fashion in other school spaces, particularly the design of personalized T-shirts and other clothing, the data unit foregrounded art and design activities that centered students' stories and esthetics as they designed T-shirts with their data art. One of the central goals of the unit was to encourage students to engage in critical analysis through their stories, particularly in illuminating data's role in reproducing educational injustice. This study was guided by the following research questions: In what ways do students use data, including information that they generate and that is generated about them and their communities, for multiple purposes? How do students craft representations of information that connect their interests, identities, and knowledge with broader social, cultural, and political issues?

Study Design

A nonselective public high school in a historically underfunded district, CDS drew its population from neighborhoods across the city; in the 2017–2018 school year, the school's 252 students identified primarily as African American (75%) and Latinx (17%), as well as mixed race (3%), White (3%), Asian (1%), and Native American (1%). All of the students at the school were eligible for free or reduced-price lunch, and each student received an individual Chromebook for school use via grant-funding. The research team was comprised of four cis-gendered women, two of whom had long-standing relationships with older students and teachers at the school; the teacher and three researchers are White (including the author) and one researcher is African American. These identities were salient to the study about issues of race, gender, and power in relation to data, and all team members worked explicitly to address these issues in conversation with students, while recognizing the power asymmetries in relationships between the university-based researchers and school community members.

A central way the school engaged students in problem-solving activities was via its interdisciplinary makerspaces where students learned through hands-on projects; this study was conducted in the media production makerspace (MPM). The MPM was a large space with cameras, lighting kits, sound mixing equipment, wheeled tables, computers with media software, and large-scale printers procured through grants and partnerships. The veteran teacher of the MPM, a photographer and media artist, Mr. Johns was a well-liked member of the school community who regularly tried to infuse his media arts curriculum with culturally relevant materials across content areas. A mix of 10th, 11th, and 12th graders were assigned to his lab for one semester for required arts credit. Students operated fairly autonomously in the lab, often working individually and in small table groups; Mr. J would convene

the whole class at the beginning of each period to give daily instruction, and then students would participate in project work at their own pace.

The data reported here were collected in the spring semester of 2018, focused on 31 students in three periods of media arts. As designed by Mr. J, the curriculum involved four primary activities:

1. Defining data: Students worked with publicly available data to see how data were collected, by whom, and in what forms (e.g., looking at charts and graphs about teen beliefs about race from different sources). In these opening activities, Mr. J defined data as information that was situated and shaped by people's agendas and beliefs.
2. Using data tools: Mr. J introduced a number of tools for analyzing data, like using Google Trends to compare two phenomena over time (e.g., Adidas and Nike sales) and playing with DataBasic web tools (e.g., to analyze song lyrics).
3. Collecting data: Students were introduced to the Dear Data (dear-data.com) project (two graphic designers exchanging data postcards) as a model for the unit to guide their individual projects of collecting personal data for a week.
4. Visualizing data: Students watched videos about dynamic data visualization, explored online data art, and analyzed their data. They then drew a visualization of their data story (similar to visualizations in the *Dear Data* book), developed a key, created a scan of both images, printed those on transparencies, and ironed them onto T-shirts (see [Figure 1](#)).

In the spring semester, Mr. J made a number of adjustments to the pace and focus of these activities based upon our findings from the first semester (not reported here). The three changes for the spring semester can be summarized as: (1) making data immediately relevant to youth (connecting data to their personal lives and interests from the beginning of the unit); (2) emphasizing data as replete with stories (framing data as interpretable resources); and (3) clarifying the data collection and analysis process (helping students identify concrete and salient variables using Google Sheets).

Data Sources and Analysis

Data are reported for 31 students in the spring semester who consented to participate in the university and district-approved study. One member of the research team participated in the MPM for at least one period each schoolday, acting as participant-observers and collecting observational, artifactual, and interview data. Observational data included 28 field notes, 20 audio recordings of class sessions (which were logged and tagged to field notes), and audio



FIGURE 1 T-shirt production process.

recordings of informal conversations with students and teachers. Artifactual data included photos of students' work as well as all student projects. Pre- and post-survey data included information about how students conceived of data and its role in their lives. Also, 21 semi-structured interviews with students were conducted individually and in small groups at the end of the semester.

Data were analyzed iteratively using qualitative data analysis software. I began by reading data holistically and writing analytic memos to capture in-the-moment sense-making and engage in grounded theory building (Strauss & Corbin, 2015). The initial set of 16 "in vivo" codes derived from this initial pass through the data described students' key insights using their language; those 16 codes were collapsed into six categories: *enjoyment* (what youth described as bringing them pleasure); *challenges* (what they found difficult); *representation* (how they made decisions about what to represent and how); *change* (how they understood

themselves or their thinking as shifting); *personal connection* (how data reflected their interests, identities); *data use* (how they defined and used data). I also used the three design principles in the curriculum as additional descriptive codes to learn how students took them up in their thinking and activity: *relevance* (making data relevant to youth); *data stories* (seeing data as interpretable resources with multiple stories); and *process* (making the process of data collection/analysis clear and accessible). These nine codes were then used to engage in a first round of descriptive coding of the fieldnotes, interview transcripts, audio logs, surveys, and student artifacts (Miles, Huberman, & Saldaña, 2013).

Findings from this initial coding were then read in relation to scholarship about critical data literacies. I adapted Philip et al.'s (2013) 5-part data framework for democratic participation as a set of theoretical codes for second round coding (Miles et al., 2013): Dimension 1—*language/tool use* (students developing proficiency in using tools for collecting and interpreting data as well as fluency in using disciplinary language); Dimension 2—*identity* (students seeing themselves as people who can use data for their own purposes); Dimension 3—*purpose* (students seeing data as useful for addressing societal and personal issues of importance); Dimension 4—*ideology* (students understanding data not as neutral or objective but shaped by beliefs and assumptions); and Dimension 5—*knowledge construction* (students understanding the affordances and limitations in how disciplinary knowledge is generated and used, particularly for historically marginalized groups).

I mapped descriptive codes to theoretical ones to identify two central ways that students shifted in the development of their critical data literacies. First, I found evidence that the majority of students reframed their *identity* as data users over time, seeing themselves as people who could use data for their own purposes. This shift in identity was influenced by what brought them *enjoyment*, how they saw themselves *change*, and the *personal connections* and *relevance* of data to their lives. Second, all students reframed their understandings of data's multiple *purposes*, seeing data as useful for addressing issues of importance to them. Their understanding of data's multiple purposes was tied to the *process* in collecting, analyzing, and representing data, including the *challenges* they identified, their *data use* in the classroom, and the *data stories* and *representations* students explored. Given space constraints, this paper focuses on the two most salient dimensions of critical data literacies that emerged in the data (identity and purpose) and does not explore the other dimensions in depth.

FINDINGS

This section presents findings about how students began to develop critical data literacies over the course of the unit in relation to two of the categories outlined by Philip et al. (2013)—in thinking about themselves as people who could use data for

their own ends (dimension 2) and by seeing data as tools to be used for multiple purposes, especially in addressing issues of personal importance (dimension 3).

Expressing Identities: Seeing Selves as Data Agents

In their pre-survey responses, students defined data similarly to students in Acker and Bowler (2018) study—as information that others generated. Most students (82%) identified data as information or numbers, facts, and graphs (“Facts and statistics collected together for reference or analysis”), with some (8%) responding with related descriptions (e.g., “a piece of work that you have accumulated to state a claim”) and others (10%) linking data to networks/phones (“keep phone moving fast”). These definitions reflected common perceptions that data exist in the world—information that students can “gather,” “collect,” “calculate,” “analyze,” or “compare.” These facts were seen as autonomous entities ready to be collected or analyzed. Students could check how much data their phone had left or insert a chart or graph into a science paper, but none framed data as something they participated in generating or shaping.

The inquiry focus of the data unit offered a different way of thinking about data as rooted in their lives. Choosing topics based on their weekly activities proved challenging, with many students beginning with something they described as “easy” or “simple,” like what they ate for breakfast or how long it took them to get to school. Mr. J pushed students to choose something that mattered to them, a genuine inquiry in which they could learn something about themselves. As a result, students chose topics that fell into three categories: personal habits (e.g., cursing, eating, nail biting); media use (e.g., gaming, social media, YouTube viewing, phone use, music); and activities (e.g., walking, talking, singing). Tracking their data in a Google spreadsheet helped students refine their focus and the variables in their inquiry. While students encountered challenges in collecting data (forgetting to record data, changing variables), many agreed with 11th grader Dion that, “It’s not that hard to do data on your own.” The personal nature of the topics—and especially autonomy over choosing those topics—was the highlight of the unit for students in the post-survey. As 10th grader Kanona said, “what I liked was that everyone got to pick their own thing and that no one had to do the same thing.”

The personal nature of students’ inquiries expanded what they thought “counted” as data to include seeing their lives as data: their narratives, art, interactions with others. For Kanona, the unit had personal relevance because it invited her to think differently about her artistic practice. She collected a week of data about the frequency, places, and reasons she drew, a topic motivated by people who told her she drew a lot. She said in her post-survey, “I didn’t believe them but I kinda started thinking do I really draw that much. So I used that as a way to show how much I draw in a week and turns out I do way more than

I thought. Two drawings a day so by the seventh day I made 14 drawings (wow).” To represent her data, she designed a semi-colon (Figure 2) “because authors use it to show that a story is never finished.” In linking her artistic practice to authorship, Kanona made explicit the relationship between art and writing and affirmed her role as an author of her own data story. Her data story confirmed that she was a prolific artist (“I realized that I draw a lot ... and it [the design] shows that I am going to do more drawing”), an identity that she came to embrace more fully through learning about herself in the data unit. By framing her art as a form of data, Kanona came to see her life as a text that she could author—a story continually being shaped and told. As Kanona summed it up, “Data comes in all different types of like, shapes.”

Part of the work of seeing themselves as producers of data involved re-seeing everyday activities as data. Eleventh grader Jasper collected data on a week of phone calls (Figure 3), explaining that he chose the topic because it was something central in his life: “I’m on the phone a lot. So I’m like, “Why wouldn’t I pick something that I do all the time in life?” So I decided to do a week of phone calls mixed with emotion. So what I collected data on was each phone call, who was the phone call with, and my emotion afterward.” He discovered he enjoyed talking to his parents (“I just like listening to them”) as well as his boyfriend. For Jasper, what was important was the insight into himself he gained: “What stood out the most was just looking back at the process. Like the days that I took, actually putting in the data of it and then noticing certain things that I never ever noticed about myself at first. And then looking back at it, I’m like, ‘Wow, this is just something I do every day that I turned into something really cool.’” It was the *everydayness* of the data collection that made it powerful for Jasper—choosing something meaningful that happened every day and interpreting it in ways that provided new insight.

Students began to embrace their identities as producers, architects, and authors of data through Mr. J’s repeated positioning of them as authorities over their data collection and interpretation. In the opening introduction to the unit, Mr. J offered his rationale:

If you don’t understand data, people, companies, governments, schools, they’re going to take advantage of you. ... And as we go through time there’s going to be more and more people who just don’t get it and fewer people in the world who understand these things. And I think that you guys should be on that side of people that understand these things. It can help you learn about yourself, it can help you learn about the world around you, and, hopefully, in the future you can become the people creating some of these tools to figure things out. [2/21/18 Class]

He repeated throughout the unit that he wanted students to be the creators of these tools, to learn about themselves and the world through data. And students took up that framing. As 10th grader, Janae explained: “People like us, kids, we



FIGURE 2 Kanona's data visualization about art.

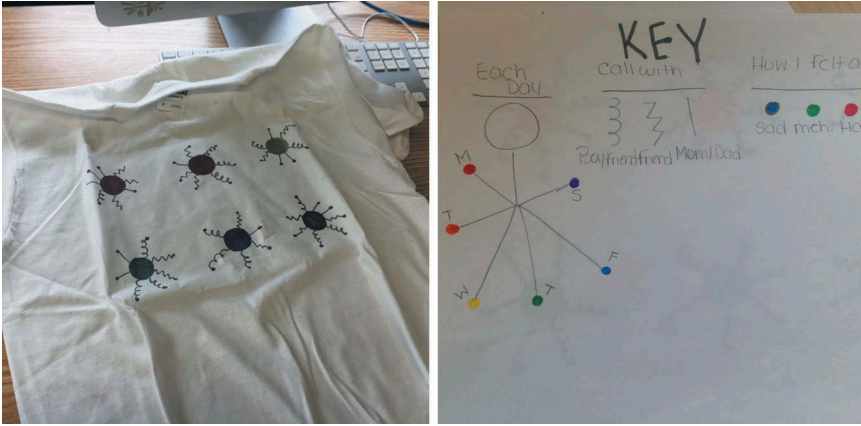


FIGURE 3 Jasper's T-shirt design and key.

don't be setting data So for [the teacher] to just be like 'Make up your own,' it felt creative. Because we learned on our own the data that we do." The idea that they—as kids—could “be setting data” and expanding what counts as data based on their lived experiences were powerful. Such agentic positioning, understanding oneself to be a maker and doer of data science, is a central tenet of critical data literacies and fundamentally intertwined with academic knowledge building (Philip et al., 2013).

Authoring Data Stories: Using Data for Multiple Purposes

A major shift for students involved understanding data as contextualized resources available for multiple purposes. One purpose students saw for data was as a tool to know something. Certainly, as Kanona and Jasper show, students saw data as a tool to learn about themselves. But they also saw data as a means to learn about other issues that mattered to them. Senior Alesha was interested in learning more about how to keep her skin healthy, tracking how skincare projects affected her skin “because I take my skincare seriously.” Senior Chantelle collected data about web traffic to her commercial site to learn who visited and how much money she earned, saying that the project “represents my work but not me [personally].” Senior Ana extended the data collection process she learned from the data unit (tracking how she spent her time) to apply to her senior project. In studying drug abuse in her community, she interviewed neighbors and family members about their experiences, created a Google spreadsheet, and analyzed and visualized that data to include in her final report. In all of these examples, students saw data as multiple, replete with

stories that they could turn to their varied purposes—whether that was learning about the right skincare products, analyzing web traffic for e-commerce, or representing her community’s experiences to make an argument.

Some students saw data as a communicative tool, one that could convey messages to an audience. The T-shirt, as a public artifact, certainly highlighted

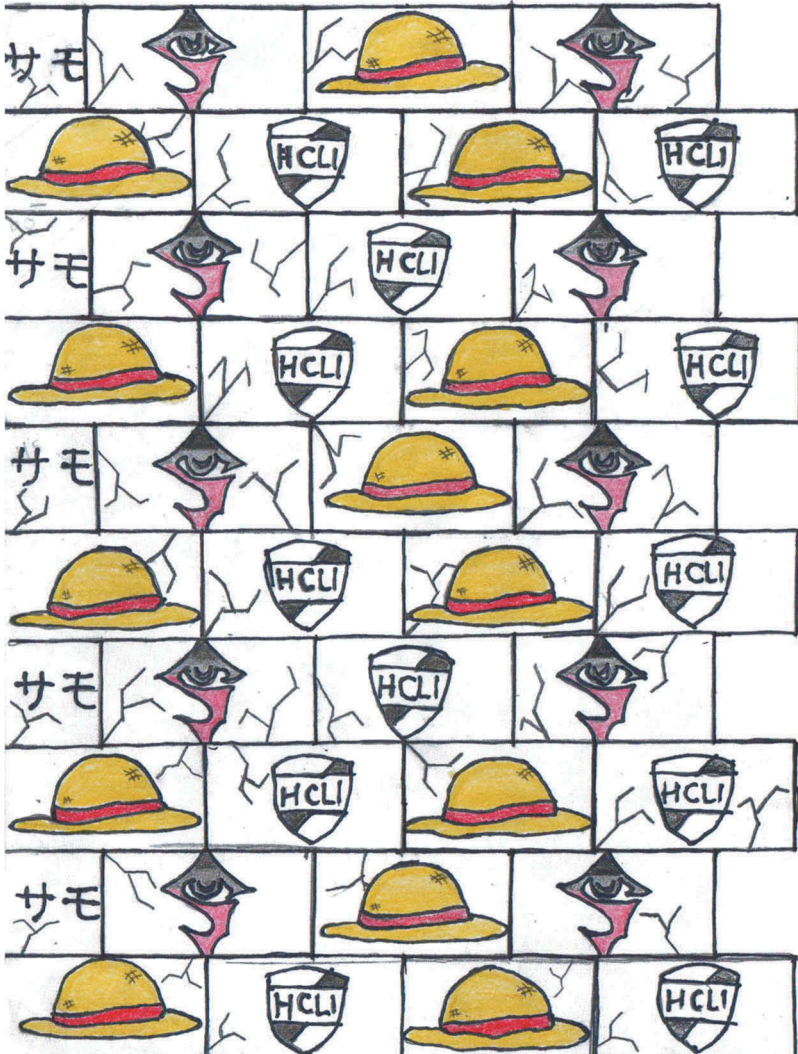


FIGURE 4 Javier’s data visualization about anime.

the communicative purpose of data. For 11th grader Javier, the data design activity offered him the opportunity to signal his love of anime and his hometown pride to others (Figure 4). Each element was carefully chosen, with bricks representing the number of anime episodes watched and symbols representing specific shows, with the goal “to help people both realize new things about me and to see what type of anime interests me.” This outwardly turned purpose was reinforced by the T-shirt as a public artifact (Javier wore his shirt often), affirming his identity as a fan for insiders who recognized the symbols (“it represents me more than anyone thinks”). He found the project engaging because “you just pour your imagination into it, and then when you finally get done this feels like you have a nice achievement, accomplished a life goal basically.” For Javier, the data story represented on the shirt was more than an exercise—it was a piece of himself that he was putting into the world and sharing with others. Data, in this way, could help him communicate something vital about himself.

While data were recognized as a communicative tool that realization was not as motivating for some students as it was for Javier. Mr. J encouraged students to think about how much they wanted to share with others as they moved from analysis to visualization, asking regularly, “What data story do you want to tell?” Several students chose to tell a public story that was different from what they originally imagined, uncertain they wanted to put a more private data story on their public T-shirts. Others left keys off their shirts, letting the design be ambiguous. Alesha was one who grappled with whether to include the key, saying that her design could be read in multiple ways: “I came up with my own unique data chart that no one will understand unless I tell them.” Several students changed their topic altogether, abandoning topics too personal (e.g., measuring a father’s anger) or ones that felt too personally revealing (e.g., eating junk food). Jasper found this capaciousness of data to be important in shaping his thinking about its role as communicative tool: “You can really collect data on anything, and it’s so different, the type of ways that you can present it, explain it. I can show my shirt to somebody, and they would have a whole different analogy or a whole different interpretation of what mine was. So that’s what I like about data.” Jasper liked the fact that data were open to interpretation.

Some students sought to capitalize on the openness of data by using the visualizations as a tool to control how they communicated their stories to audiences. Hannah, for example, was an 11th-grade student with a serious boyfriend at another school. Some of her friends questioned this relationship, and Hannah wanted to create a T-shirt with a dual purpose—as a kind of love letter to her boyfriend as well as something that could represent her love to others. She went through an elaborate design process, drawing a number of possible prototypes and making more than one shirt as she decided how best to accomplish those dual purposes. In Figure 5, her initial idea involved having

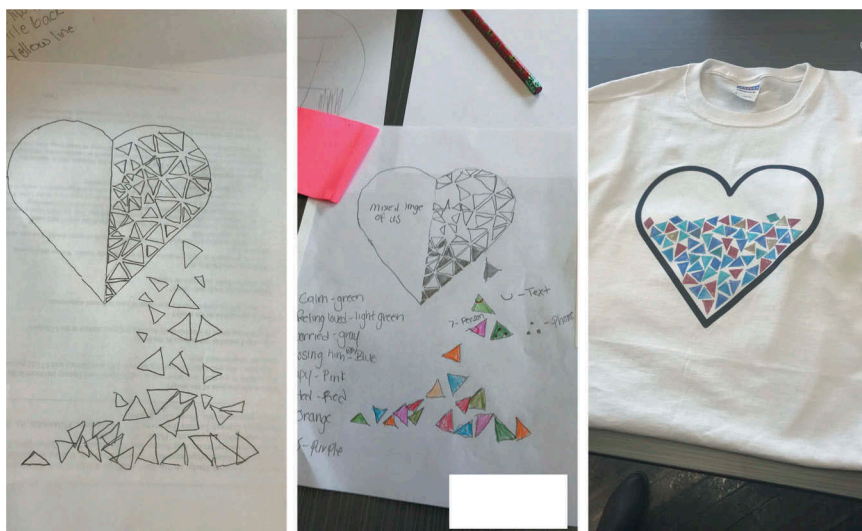


FIGURE 5 Hannah's data visualization drafts.

half of a heart containing her findings, filled with differently colored triangles that represented the various emotions she experienced when she interacted with her boyfriend in a week. As she iterated on the design, she drew some of the triangles as falling outside the heart (the negative emotions), but then realized that would communicate a potentially damaging message about her feelings that she did not mean to convey. Her “final” image on the T-shirt involved triangles filling most of the heart, without pieces falling out, to represent both the fullness of emotion as well as the space for more conversations and love at the top. These efforts to use data as a communicative tool—to shape others’ perceptions and convey a particular message—helped students realize not just that they could use data for myriad purposes but that data were open to interpretation and shaped by the desires, beliefs, and assumptions of people. As authors of data stories, they could exploit that capaciousness for their personal purposes—one of the key insights in critical data literacies.

DISCUSSION

This article reported findings about how students developed particular aspects of critical data literacies, specifically in reframing their understandings about themselves as data agents and expanding what they understood as data and its purposes. The study demonstrates the importance of youth seeing data as

personally relevant, as they brought their identities into their learning in meaningful ways. Certainly, students like Kanona, Jasper, Javier, and Hannah came to see themselves as people who could use data for their own purposes, with data representing a powerful tool for telling their personal stories and data visualization an esthetically powerful communicative medium. They also made initial inroads in thinking about the politics of knowledge Philip et al. (2013) discuss, particularly in understanding data as “premised on a set of assumptions, which are rooted in particular world views” and which may “obscure certain perspectives and histories” and highlight others (p. 115). As students redesigned their data collection strategies and pored through data to understand the potential stories they could tell, they became increasingly attuned to the socially situated nature of data and its rootedness in their own assumptions.

However, other aspects of critical data literacies—particularly constructing knowledge about the social, cultural, and political purposes of data and its racialized dimensions (Philip et al., 2013)—were less visible in the study. While one of the central aims in the data literacy unit was to emphasize how students could use data to work “toward a society that is more just and equitable” (p. 115), a central goal of a critical approach to using data (see also Pangrazio & Selwyn, 2018), the reality was that other goals, such as using data to understand oneself in new ways and engaging the esthetic dimensions of storytelling with data visualizations, became foregrounded in instruction and students’ subsequent inquiries. These findings about how students may not focus their projects on culturally or societally relevant issues reflect those in the studies of Kafai et al. (2014) and Enyedy et al. (2011), which suggest that perhaps students need additional opportunities to deepen their inquiries and curricula that include explicit links between the personal, social, political, and cultural. This study points to the need for explicit pedagogical and infrastructural support to create critical and sustained engagement with culturally relevant data practices. It also highlights the role of power in these pedagogical initiatives as youth and teachers navigate how to make central issues of race, equity, and justice in historically oppressive institutional spaces (Vakil et al., 2016)—reinforcing Philip et al. (2016) conclusions that such critically turned work, particularly around racial data literacy, is both challenging and essential.

FUTURE DIRECTIONS

Rooted in social design research, this study focused on designing consequential educational opportunities with and for young people based on principles of equity and historicity. Part of this effort involved reframing what counted as data to include students’ lived everyday experiences, storytelling, and art—by

institutionally recognizing these as legitimate sources of knowledge and positioning students as authors of their own data stories. Such a focus on *storying* in this study—specifically, how youth narrated self and world through the data T-shirts—highlights the myriad ways data can be leveraged as a narrative tool. Students were overwhelmingly enthusiastic about exploring data’s storytelling capacities, and particularly the esthetic dimensions of storytelling offered by data visualizations. One potential direction for data science research is further exploration of the esthetic dimensions of data design, especially to understand how the artistic and communicative potentials of data intertwine with students’ uses of data for argumentation and critical reasoning.

While the students could have created other kinds of data stories (e.g., through writing, murals, presentations, etc.), the focus on creating data art—and particularly its public display via the T-shirts—was an important aspect shaping the storying process for students, one particularly relevant for students at this design-oriented school with a focus on fashion. This study’s focus on using data visualizations as a form of visual communication highlights the centrality of audience as a future direction in data literacy studies, particularly the role that potential future audiences play in shaping student-created representations using data.

The fact that this study about data literacy was located in a media makerspace seems important to emphasize. Recent scholarship has explored how makerspaces, in supporting young people’s hands-on, iterative inquiries with a variety of material and digital tools, can function as critical places for scholars, educators, communities, and young people to work collaboratively toward addressing social and educational inequities (Castek et al., 2019; Tan & Calabrese Barton, 2018). Students in this study found the media makerspace to be a generative place for negotiating relevance in the curriculum, finding meaning by contextualizing data in their lives and seeing themselves as people who could generate stories with data for their own purposes. In that sense, the project helped to reorganize students’ learning around hands-on, meaningful inquiry that shifted how they understood themselves in relation to data—a critical educational effort to widen definitions of success and knowledge in an era of accountability and marginalization that often disproportionately focuses on narrowing those definitions for youth of color (Vossoughi et al., 2016). Scholarship about youth’s making practices (e.g., Kafai et al., 2014)—also echoed in this project’s findings—suggests the need for an extended study design that allows youth to build and deepen critical inquiry over time and across multiple projects, beginning with questions of personal relevance and extending to broader social, political, and cultural issues that matter to them. One important direction for future studies involves exploring these potential relationships between critical data literacies and making/makerspaces.

What became clear through this study is that while negotiating personally relevant and meaningful inquiry is a vital starting place for designing consequential

educational efforts around critical data literacies, it is not always enough. Pedagogical approaches based on principles of equity and justice should include an explicit focus on the sociopolitical, cultural, and racialized dimensions of data, and building infrastructural support for this kind of work appears to be a critical direction for future scholarship. A central implication of this study is the importance of integrating culturally relevant curriculum around personal data literacies with cultural, political, and economic analyses of power. As youth are encouraged to develop their data stories in school contexts like this one, educators can explicitly invite in students' re-storying practices (Stornaiuolo & Thomas, 2018), whereby they challenge mainstream, deficitizing, or racialized beliefs about themselves and their communities by re-writing dominant narratives from their perspectives. Such counternarrative work highlights the sociopolitical nature of critical data literacies and the centrality of designing learning environments in which such work might flourish.

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