Data Literacies and Social Justice: Exploring Critical Data Literacies Through Sociocultural Perspectives

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Abstract: The ability to interpret, evaluate, and make data-based decisions is critical in the age of big data. Normative scripts around the use of data position them as a privileged epistemic form conferring authority through objectivity that can serve as a lever for effecting change. However, humans and materials shape how data are created and used which can reinscribe existing power relations in society at large (Van Wart, Lanouette & Parikh, 2020). Thus, research is needed on how learners can be supported to engage in critical data literacies through sociocultural perspectives. As a field intimately concerned with data-based reasoning, social justice, and design, the learning sciences is well-positioned to contribute to such an effort. This symposium brings together scholars to present theoretical frameworks and empirical studies on the design of learning spaces for critical data literacies. This collection supports a larger discussion around existing tensions, additional design considerations, and new methodologies.

Overview

Data literacies are central to civic participation and employment opportunities. These include the ability to understand the algorithms and statistics that are reified in data representations and make and critique decisions based on data. However, there is scant research on how young people can be supported in engaging in *critical* data practice around topics such as racial and gender discrimination of algorithms in society (Noble, 2018), the opaqueness of algorithm usage (Eubanks, 2018), and how data are inherently socially constructed in ways that may exclude individuals and populations. Without a critical lens on data literacies research, problematic assumptions are reproduced such as that data are objective and independent of the thought systems that create them (Kitchin, 2014), that information is static and not subject to change or reinterpretation (Pangrazio & Selwyn 2018), and that simply teaching knowledge and skills about data manipulation will spontaneously address inequities and promote social justice (Philip et al., 2013). In other words, while normative scripts around the use of data would position them as a privileged epistemic form conferring authority through objectivity to act as a lever for effecting change, how data come to exist and are marshalled for specific purposes is shaped by both human and material factors that can reinscribe existing power relations in society at large (Van Wart, Lanouette & Parikh, 2020). Thus, a *critical* data literacy practice is essential for young people to engage consequentially by recognizing and questioning inequities in data practices and being aware of the ideological, historical, and political dimensions of data production and usage.

Philip and colleagues (2013) have proposed a framework of big data for democratic participation that is rooted in both sociocultural and critical pedagogy theories. Within this view, empirical studies show classroom data visualization activities without attention to racial data literacy may not support students in developing robust data literacies and further disengage and marginalize students of color (Philip, Olivares-Pasillas, & Rocha, 2016). When designing for deep investigations into the politicized aspects of computing and data, Vakil and colleagues (2019) suggest designing learning environments through a lens of politicized trust, in which students develop solidarity with one another to mediate discussions around race, power, and data. From a design perspective, Wilkerson and Laina (2018) suggest offering opportunities for students to repurpose publicly available datasets to tell personal stories using data and then critically examining how public data embeds complex social and

scientific phenomena that may be in conflict with their personal views. However, Stornaiuolo (2020) found that while opportunities to tell personal stories helped students develop a sense of agency with respect to data, more explicit pedagogical support was needed to help them take up data as a tool to address issues of injustice or inequality.

In this context, we see the learning sciences as having an important role to play in understanding at least three interconnected views of critical data literacies through sociocultural perspectives: first, data literacy as comprehension; second, data literacy as critique; and third, data literacy as participation. In considering data literacies as comprehension, learners learn to recognize and acknowledge why and how data are inherently politically, socially, and materially constructed (Hardy, Dixon & Hsi, 2020). This includes interrogating the systems that led to the production of particular data, unpacking the impact of decisions related to the selection, structuring algorithms used to model data, and viewing data representations as tools of communication created to serve specific, non-neutral purposes. Second, considering data literacy as critique supports learners to go beyond reading data to engage in domain-specific discourses and critiques around its usage and the ways in which data can (re)produce (in)justice. This includes deeply and explicitly engaging with issues around power, ethics, privacy, race, gender, oppression, and exclusion and considering how representations (as well as the underlying data and its manipulation) can be remediated to offer alternative perspectives. Finally, considering data literacy as participation, learners start to see themselves as civic participants and agents in the generation, transformation, interpretation, and representation of data to meet specific purposes (Wise, 2020) and can be supported in enacting change in their lives and those in their communities to work towards a just, sustainable society.

Significance of contributions

The four symposium contributions focus on the sociocultural, critical, and political contexts inherently embedded, but often hidden, in data and its usage. All draw on methods, learning theories and models, and approaches to analyzing and understanding data from the learning sciences. First, building on their prior work with racial data literacy, Philip and Olivares propose a critical data literacy framework that centers political, power, and histories of oppression within disciplinary data practices. This broader framework emphasizes analytical methods of interaction analyses and heterogenous meaning making. Similarly, Van Wart, Vakil, Marshall, and Parikh investigate the political dimensions of big data learning with two case studies of students examining personal social media data and surveillance technologies. Intertwined with the political dimensions are ethical considerations of how data is collected, used, and commoditized. Lopez, Wilkerson, and Gutiérrez also take a critical lens on data literacies but focus on the sociocultural aspects of meaning making in data. Their Writing Data Stories project integrates data practices into science classrooms in which students investigate existing nutritional datasets as they relate to home food practices and broader social narratives about nutrition. Finally, Jiang and Kahn also take a sociocultural lens to frame data science learning as they investigate how students make connections between personal family mobility and national and global migration using existing datasets and visualization tools. In their study, students reconciled how aggregated patterns in the data conflict with their personal family experiences. Together these contributions aim to promote conversations around critical data literacies through sociocultural perspectives.

Symposium format

To promote interaction, the symposium will be formatted as a panel discussion. The co-chairs will introduce the contributors and topics. Contributors will each briefly present their research, and then engage in a panel discussion facilitated by the co-chairs. Attendees of the symposium will have the opportunity to submit additional questions, comments, and discussion topics electronically through a shared online space. The co-chairs will select questions and topics from the online space and engage the panel and attendees in discussion. At the conclusion of the panel, the co-chairs will summarize the discussed topics and present future directions and collaborations. Attendees will find this panel session complementary to a related interactive poster session that provides examples of curriculum, professional development, and research on developing learners' data literacy for broader social justice purposes (Matuk & Yoon, 2020).

Racial data literacy as a step toward critical data literacy

Thomas M. Philip and Maria C. Olivares

It is increasingly recognized that data literacy is essential for new modes of civic participation and for emergent and changing sectors of the economy. This line of argument, however, is often premised on problematic assumptions that have defined previous iterations of scientific and quantitative literacies: that becoming literate

in these domains will translate into changes in civic engagement and participation in society (Feinstein, 2011). Based on cumulative work from a 6-year study of an introductory high school data science course, this paper makes the argument that a critical data literacies approach is vital if new data literacies are to genuinely engage and address social justice.

The call for critical data literacy parallels the critical turn in media studies. Extending Kellner and Share (2007), the modifier *critical* signifies (a) addressing ideology and structures of control and domination through an examination of how power and data are linked, (b) exploring contestations of power in and through data production, collection, representation, and analysis, and (c) "embracing the idea that participants are active in the process of meaning making" as they negotiate multiple "readings" of data (p. 61).

From 2010-2016, we studied the development and implementation of an introductory high school data science course that prioritized civic engagement and students' use of data to address "issues that are important to them and their communities." However, without a critical approach to data literacy, there was a recurring theme in which well-intentioned activities that were meant to encourage civic participation, student reflection, and student agency ricocheted into re-inscriptions of deficit ideologies about students, their families, and their communities (Philip, 2017; Philip et al., 2016, 2013). While the motivations for the project's efforts were grounded in stated commitments to social justice, racialized hierarchies were consistently reproduced in and through the classroom interactions that we documented and studied.

Our call for a critical approach to data literacy emphasizes (a) disciplinary specificities of data and data literacy and (b) the particular histories and processes of different forms of oppression. We are cautious that generic notions of critical data literacy will result in diluting both data literacy and the associated notion of criticality. We propose racial data literacy as a first step toward building a nuanced, multifaceted approach to critical data literacy.

Elsewhere, we have argued that students need to learn to become racially literate about data and data-literate about race (Philip et al., 2016). That is, that students need to be supported in developing racial data literacy. To expand:

> Within the contemporary context of ubiquitous digital data, an example of becoming racially literate about data is exploring how power operates in the collection, analysis, interpretation, representation, and communication of data to reproduce, challenge, or transform current societal meanings about race. An illustration of becoming data-literate about race is examining how societal meanings about race are produced, in part, by the possibilities and constraints in the collection, storage, conversion, manipulation, and representation of data sets. (Philip et al., 2016).

Through an empirical analysis of a classroom interaction, we showed how these literacies are closely related but also prioritize different lenses.

Building on our conceptualization of racial data literacy, we present in this paper, our framework of critical data literacy. Additionally, we emphasize in this framework the importance of an accompanying set of analytical commitments that prioritize interaction analysis of ideological micro-contestations, convergences, and expansions (Philip, Gupta, Elby, & Turpen, 2018) to consider the emergent heterogeneous meaning making (Rosebery, Ogonowski, DiSchino, & Warren, 2010) within spaces that center critical data literacy.

Exploring possibility and vulnerability in the era of big data and ubiquitous computing: Two case studies

Sarah Van Wart, Sepehr Vakil, Jessica Marshall, and Tapan Parikh

People increasingly use a constellation of platforms and computer-mediated systems as they go about their daily routines. These systems offer valuable information and communication services (recommendation systems, localized search, connection to friends and family) precisely because they have access to massive amounts of personal data — collected, sorted, grouped, analyzed, and repurposed at an unprecedented speed, scale, and frequency. However, making personal data available to these systems can also make individuals vulnerable to a variety of risks (e.g. surveillance, exclusion from critical material opportunities). Moreover, these risks are opaque, difficult to reason about, and disproportionately impact social groups who are already vulnerable (Eubanks, 2018). We argue that in order to foster a robust computing and data literacy, it is important to help young people to understand how these systems work, and the possibilities and risks they introduce. Below, we briefly describe two approaches that we have taken to help high school students explore some of these socio-technical ideas.

Case 1: Platforms

In one design experiment (conducted by Van Wart & Parikh), carried out in a 5-week summer program, students examined some of the computing and data technologies that powered social media platforms. Students queried and inspected social media data using Twitter, Instagram, and SoundCloud's respective public APIs (application programming interface); engaged in various coding activities; and eventually built their own web apps that interacted with live data, using HTML, CSS, and JavaScript. Some findings from this study include:

- Most students were surprised that social media data (i.e. *their* data) was so readily available and searchable "for any and all to access."

- Most students did not previously understand how networked platforms and third parties profited from data.

- Students built apps across a wide variety of themes (e.g. music apps, customized news aggregators, issue-focused apps, etc.), which they viewed as "pretty similar" to those made by regular platforms.

- Several students implemented features with important ethical implications, for instance how they operationalized ideas like "newsworthiness" or "relevance" (Noble, 2018). However, these issues were rarely explored in any depth; nor well supported within the learning environment.

Case 2: Surveillance technologies and the state

In another design experiment (conducted by Vakil), also carried out within a summer program, students examined various surveillance technologies and their uses. In particular, students investigated technologies that disproportionately target and/or impact communities of color, including (a) *Stingray*, a device sometimes used by law enforcement to 'trick' nearby cell phones into transmitting locations and other identifying data, and (b) *Twint*, a Twitter tool which allows anyone to query and analyze Twitter data by user, hashtag, topics, etc. Then, students created an infographic to explain the technical underpinnings and implications of these technologies. Some findings from this study include:

- We found that the experience of learning about ethics was itself an ethical experience. In other words, in addition to conceptually exploring the ethical tensions regarding privacy and security, students grappled with the implications of their own participation in surveillance tools.

- We also found that while students were afforded multiple opportunities to explore the ethics of technology, despite stated claims of program designers, fewer opportunities were created for students to authentically explore the computational processes operating "under the hood."

In our view, these two approaches to teaching and learning fit within a larger design space that aims to help young people (a) think through some of the ways in which data and information are collected, repurposed, and commoditized; (b) consider how these systems support/erode important social values; and (c) hopefully make these systems better as future citizens, systems designers, and engineers.

Contextualizing, historicizing, and re-authoring data-as-text in the middle school science classroom

M. Lisette Lopez, Michelle Hoda Wilkerson, and Kris Gutiérrez

The Writing Data Stories (WDS) project is based on critical commitments and theories of socio-critical literacies (Gutierrez, 2008) to support more socially just futures for non-dominant students through data and disciplinary literacy. Students use every day and disciplinary practices to craft a *syncretic* (Gutierrez & Jurow, 2016) data narrative or *data story*. A syncretic data story weaves everyday practices and argumentation with analysis and transformation of data sets to support socio-scientific argumentation. Students argue "with and about" public data sets in service of personally and socially relevant goals. Wilkerson and colleagues' (Wilkerson, et al., 2018; Erickson, Wilkerson, Finzer & Reichsmann, 2019) data moves are central to a data story. The data move framework involves treating datasets as scientific texts that can be "re-authored" by performing data manipulations that align existing data with students' personal and sociocritical reflections. Linking to work on syncretic texts, our theory is that by exploring connections and disconnections between scientific data and students' experiences, both student knowledge and the provided data become contextualized within broader social communities and histories. This addresses pervasive treatment of data as objective, ahistorical, and unproblematic within the science context (Duschl, 2008; Manz, 2016) and more broadly challenges the depoliticized nature of data in the social discourse (Philip, Olivares-Pasilla, & Rocha, 2016). In WDS, students study conventions of everyday practices that reflect and can support learning conventions in data-based arguments. This approach

values everyday student resources, challenging deficit views of non-dominant students (Gutierrez, Morales & Martinez, 2009), while supporting learning of data literacy.

During the 2019-2020 academic year, we have partnered with two 6th grade teachers at one junior high school in a suburban industrial city in the eastern San Francisco Bay Area. We have been co-developing with these teachers a series of four units. In the first two units on ads and nutrition, students analyze their own food practices, everyday strategies they use to convince others, arguments in commercials for breakfast cereals, and nutritional data from a public database (Duursma, 2019). As they look for patterns in data, they interpret those patterns relative to their representations of self, social narratives that normalize only particular ideas of what constitutes a "healthy breakfast." They make data moves to investigate and make claims about issues like food access, and marketing. In the second two units, students will engage with current issues and public data sets around climate change, investigating questions relevant to their lives and communities.

The project is currently in the first year of a three-year endeavor to pilot, revise, and offer curriculum materials and lessons for researchers about a syncretic approach to data literacy that will support powerful engagement by nondominant students. The WDS project is an early effort to design and implement a syncretic approach in a secondary science classroom. Emerging findings to date concern the challenges of crafting syncretic data literacy in secondary classrooms. This includes identifying genres and conventions of everyday practice that can be related to data moves and navigating the demands of science standards and testing. We are experimenting with a range of strategies to support curriculum co-design and adaptation by teachers to meet district and day-day needs. We are also identifying modes of teacher learning to build teacher capacity for a syncretic pedagogy. This includes findings about how standard teacher planning practices around rubrics, learning objectives, learning progressions and formative assessment can support syncretic data stories, and can be used to convey and support syncretic goals in the classroom. Data sources include video of classroom instruction, student group work, and teacher planning sessions video, student and curricular artifacts, and planning documents.

Emerging findings have the potential to inform teacher preparation and curricular design, in particular with respect to the critical analysis of public data sets in the science classroom. These findings are relevant to developing syncretic approaches – including syncretic pedagogy and texts - in the science education context and beyond. Within the science classroom, they directly address what has been identified as a dearth of culturally-relevant approaches to data analysis in NGSS-aligned curricula (Brown, 2017). More generally, they point to ways that we can support teachers across domains in reorganizing learning to make non-dominant students' and communities' everyday practices and histories a valued and integral part of inquiry education.

Data patterns and missing data: Complex issues in designs for learning with aggregated data in family migration context

Shiyan Jiang and Jennifer B. Kahn

Data science education emerged as a response to the need for preparing data scientists who can effectively solve today's many big data problems (Boyd & Crawford, 2012; Enyedy & Mukhopadhyay, 2007; Lee & Wilkerson, 2018). Aggregated large data sets, like US Census data, present particular challenges for users, such as issues around what data reveal or hide and who or what is included and excluded within the datasets. These challenges become clearer when data exploration is situated within a sociocultural context. More research is needed to explore learning opportunities in order to identify when an instructor's intervention would be helpful to support learning with aggregated data. In this study, we take a first step towards identifying learning opportunities by investigating complex issues in assembling models and stories with aggregated, large socioeconomic data sets about the *family geobiography*, or family migration history. Our research question is the following: How did youth experiences' storytelling and modeling with geo-referenced, socioeconomic, aggregated data support deep inquiry and understandings of the aggregated data and tools?

In the present study, 17 middle and high school youth created family migration storylines with two data visualization technologies, Gapminder (gapminder.org) and Social Explorer (socialexplorer.com) in a free summer workshop at a city public library. The workshop was designed to engage youth in exploring the connection between personal family mobility and national and global migration. In this study, we used interaction analysis approach to analyze screen recordings of students' interactions with data visualization technologies as well as associated discussions with instructors and peers.

First, we found that youth were aware that individual differences were neglected in aggregated data patterns by linking personal stories with global trends. Specifically, participants noticed that the aggregated pattern was conflicted with their family experiences. The conflict provided unique learning opportunities for participants to understand that individual differences were lost in aggregation, and stories told with the aggregated data could be problematic for explaining their or their family's individual cases.

Second, *data surprises* (Jiang & Kahn, 2019) drove the youth's exploration of social and historical events that lead to changes in data patterns. A data surprise occurred when youth noticed outlier data, such as an obvious decrease in a line chart with an increasing trend or a very dark census tract in a larger lightly-shaded county. For instance, one participant, when exploring the population making less than the average household income in 1960 in her city, noticed that a downtown census tract was shaded very dark; this led to the discovery of historical residential and social segregation patterns. The data surprise offered a venue for participants to learn social and historical events while exploring data visualizations.

Third, participants highlighted data patterns with flexibility in encoding data visually to show that a specific population historically faced socioeconomic hardship. For example, one participant changed the household income threshold from less than $25,000 to $7,000 because she intended to show that her family was a part of a population that was not earning enough in 1960 and support a storyline of her family moving for better economic opportunities. Data visual encoding thus allowed participants to leverage data for storytelling.

Last, participants used data approximation to address the issue of missing data. When participants encountered a lack of data in a particular year or region and could not find a variable they desired, they used data of the closest survey year and a similar region or variables that had a similar cause–result relations with the variable of interest. Missing data was common while exploring data visualizations; instructors should help participants engage in evaluating the model assumptions that underlie data approximation decisions.

Overall, the findings from this study provide promising insights into technology and curriculum design for promoting learning with aggregated data and visualization technologies. In particular, our findings reveal challenges and opportunities when using aggregated datasets in a sociocultural context for data exploration.

Discussion and implications

Given the increased recognition of data literacies as central for civic participation, yet the inherent socio-political nature of data construction and usage, this symposium fosters an urgent conversation around how to characterize and design learning spaces to support critical data literacies through a sociocultural lens. Drawing on the learning sciences' ongoing commitment to in data-based reasoning, social justice and design, the multiple bodies of work brought together here support a larger discussion around existing tensions, additional design considerations, and new methodologies needed to address the complexities of effectively developing critical data literacies. We thus pose the following questions to the symposium participants and the larger learning sciences community concerned with these issues.

Technical and social dimensions

The studies included in this symposium each put a different emphasis on 'the technical' (i.e. coding, design) and 'the socio-political' (i.e. viewing systems in terms of race, equity, and civic rights). What does the integration of these two dimensions look like in various contexts and disciplinary domains? What other dimensions beyond technical and socio-political need to be considered to move towards a complete account of data literacies?

Methodological considerations

Investigating new data literacies in socio-political contexts requires methodological approaches that center power relations and structural inequities to make sense of learning rather than considering such inequities at the margins of analyses or not at all. What methodological frameworks and approaches align with critical data literacies and learning? What others can be adapted for this end?

Local and global considerations

How can we create spaces where young people are able to not only consider broader implications of computer-mediated systems, but also locate themselves, their communities, and/or their interests within these inquiries in empowering ways?

The designed and the emergent

Some of the most generative moments of wrestling with the social implications of data in the studies above were emergent, rather than pre-planned. Given the potential of these teachable moments, how can we better anticipate and leverage these situations for learning?

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