Guest Editorial: Learning at the Intersection of Data Literacy and Social Justice

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ABSTRACT: With growing awareness of, and attention to, the potential of data to inform decisions across contexts, has come an increasing recognition and need to develop data literacy strategies that support people to learn to be critical of data, given this consequential nature of data use (and abuse). To achieve a just society, inequities in both capacity for data literacy, and the applications of data in society, must be addressed. A key aim is to create learning experiences that engage learners with issues of power and inequity, including those typically marginalized by data literacy education. In this way, data literacy and social justice learning goals are intertwined, and mutually supportive, in developing data literacy in learning about, through, and for social justice. This special issue assembles five empirical studies on learning at the intersection of data literacy and social justice, and that illustrate various approaches to intertwining data science and social justice learning goals. They moreover highlight the importance of the learning sciences as a perspective for understanding how people learn in specific contexts of data justice. This essay reflects on themes raised by these contributions, and offers a framework for conceptualizing the intersections between the learning of data literacy and justice. In particular, we draw on existing distinctions between "reading" and "writing the world," and propose a mapping of data literacy justice activities from data comprehension to participation, and from thin to thick justice.

Keywords: Data justice, Numeracy, Mathematics education, Civics education, Equity

1. Why data literacy and justice?

Recent global events have shown the role that data can play in both causing and answering social injustices. The explosion of Big Data into all aspects of society, from its use in tracking physical and online activity, to its role in making personal and governmental decisions; as well as technological advances with respect to generating and accessing data have, on the one hand, empowered people to participate in society through the generation and use of data. Correspondingly, we have witnessed a growing thirst for data to inform both local and global strategies for addressing society's grand challenges, from climate change to pandemics (Lee & Campbell, 2020; Pennington et al., 2020). However, on the other hand, unawareness of how actions produce traces of data, and to whom these are available, have made communities more vulnerable to abuse by those who would commodify that data (Pangrazio & Selwyn, 2019; Raffaghelli, 2020). Similarly, lack of awareness and attention to the inherent biases of algorithms that predict and categorize people using big data have perpetuated racial, gender, and economic inequities (Buolamwini & Selwyn, 2018; Noble, 2018; O'Neil, 2016; Vakil & Higgs, 2019). Beyond question, the destructive impacts of unregulated uses of algorithms and big data have been felt across sectors including education, law enforcement, and healthcare (O'Neil, 2016).

The inaugural "Data Justice" conference, held in 2018 in recognition of the intersection of datafication and social justice concerns, noted "a need to position data in a way that engages more explicitly with questions of power, politics, inclusion and interests, as well as established notions of ethics, autonomy, trust, accountability, governance and citizenship" (Dencik et al., 2019, p. 874). Others have similarly advanced the notion of data justice, that is, "fairness in the way people are made visible, represented and treated as a result of their production of digital data" (Taylor, 2017, p. 1), an idea that is relevant to various realms of justice, including racial justice, economic justice, environmental justice, and spatial justice. More specifically, data justice is characterized by (1) visibility in terms of privacy and representation, (2) engagement in terms of autonomy in using data technologies, and accessing the benefits of data, and (3) non-discrimination, manifested by the challenge and pre-emption of bias and discrimination (Taylor, 2017).

Yet, learning to engage with data justice assumes a certain level of understanding the nature of data, how data are produced, and how data can be used (Raffaghelli, 2020). A degree of quantitative skills has long been recognized as central for successful participation in society (Gal, 2002; PIAAC Numeracy Expert Group 2009; Steen 2004; Engel, 2017), important in the workplace and valued by employers (Durrani & Tariq 2012; FitzSimons & Coben

2009). It is also noted that attention to the intersection of mathematics education and social justice is not new (e.g., Frankenstein, 1983). For example, researchers have explored ways to support the learning of mathematics through learners' critical examination of injustices toward low-income and minoritized communities, as evidenced in data that reveal disproportionate police stops and inequitable housing prices between communities (Gutstein, 2003; Gutstein, 2006).

However, in response to the injustices brought about—and brought to light—by the exponential growth in data, definitions of data literacy in education have expanded over the years. Once focused on quantitative and procedural skills, such as manipulating data sets, selecting and applying appropriate analyses, and making data-based inferences and arguments (See this overview of United States K-12 standards related to data literacy, https://tinyurl.com/dataliteracy-gdoc, Common Core State Standards Initiative, 2010; Franklin et al., 2007; NGSS Lead States, 2013), data literacy now encompasses abilities to critically reason with and about data; that is, to evaluate data and arguments with attention to the contexts in which data are produced and used, and to the people that are impacted (American Statistical Association, 2016).

This critical approach to data literacy is broadly relevant to, and urgently needed by all, a point reflected in several notable mainstream publications (e.g., D'Ignazio & Klein, 2020; Gigerenzer, 2014; Kahneman 2011; Levitin 2016; O'Neil, 2016). As citizens, we engage data literacy across (1) our general understanding of data in society regarding, for example, the economy ("data thinking"), (2) in our own ethical engagements with data ("data doing"), and (3) in more proactive data use, protection, and support for other's engagement with ("data participation") (Carmi et al., 2020; Yates et al., 2001). The creation, collection, and interpretation of data for specific purposes (and, where repurposed), is shaped by the social and material contexts in which the data is collected and used, reflecting features of power and culture (Stone, 2018; Van Wart et al., 2020). People must learn to be critical of data given the consequential nature of its use (and abuse), through questioning the socio-historical context of that data.

Yet, even the question of preparing a data literate citizenry is entangled in social justice issues. Notably, there remain inequitable outcomes in data-related disciplines (as across STEM) including low percentages of women and BIPOC (Black, Indigenous, and People of Color) individuals earning engineering, computer science, mathematics, and statistics degrees (NCSES, 2021), with some inequitable outcomes within the disciplines beginning at the school level (Quinn & Cooc, 2015). Thus, failing to address inequities in data literacy risks further perpetuating disparities in health, wealth, education, and employment. It follows that we cannot achieve a just society without addressing both the inequities in data literacy capacity, as well as the inequities caused by data's applications.

Building on these ideas, this special issue advances the significance of applying a learning research lens to understand the relationships between data literacy and data justice. This idea stands on the premise that, on the one hand, building data literacy can empower individuals and communities to produce, interpret and use data; and on the other, that building data literacy alone is not a panacea to social injustice (Philip et al., 2013). Rather, a focus on social justice is necessary for learners to engage critically with the underlying biases inherent in the conceptualization, operationalization, and interpretation of data projects (Kitchin, 2014); and to see data as models open to change, interpretation, and reinterpretation (Pangrazio & Selwyn 2018), rather than static and objective truths. Part of achieving this goal is through the design of learning experiences that support learners typically marginalized by data and data literacy education in gaining the statistical and mathematical skills to work with data; and that engage learners with issues of power and inequities in society with data. Thus, powerful learning experiences that support data literacy and social justice are ones in which statistical and social justice learning goals are intertwined and mutually supportive of one another.

This special issue assembles five empirical studies on learning at the intersection of data literacy and social justice, and that illustrate various approaches to intertwining data science and social justice learning goals. They moreover highlight the importance of the learning sciences as a perspective for understanding how people learn in specific contexts of data justice, including high school classrooms (Khan et al., 2022; Louie et al., 2022), out-of-school programs for economically disadvantaged students and students of color (Arastoopour Irgens et al., 2022; Khan et al., 2022); a training program for marginalized data workers (Shapiro et al., 2022), and a professional development workshop for students in higher education (Bhargava et al., 2022). Together, these contributions demonstrate approaches to data literacy via learning about, through, and for social justice.

2. Learning at the intersection of data literacy and data justice

By way of framing the contributions in this issue, this essay provides a conceptualization of the relationship between data literacy and social justice into what we refer to as *data literacy justice*. Existing conceptualizations of social justice oriented mathematics education identifies two interrelated goals to be pursued in tandem, and that Gutierrez (2009) has distinguished as "learning to play the game" vs. "learning to change the game." By "playing the game" learners develop the foundational domain competencies (e.g., working with data tables and graphs, selecting appropriate analyses), necessary to eliminate inequities in academic performance based on demographics. Meanwhile, by "changing the game," learners "read the world" (Gutstein, 2006), using these domain competencies to develop a critical understanding of social phenomena. Learners may further use these competencies and understandings to "write the world" (Gutstein, 2006), that is, to evoke social change through awareness, understanding, and advocacy (Xenofontos et al., 2021).

Rather than two opposing ends of a spectrum, these goals are deeply integrated. That is, data literacy pedagogy intended to simultaneously develop social justice literacy must go beyond only building foundational mathematics competencies. It must guide learners to recognize and respond to how data reflect the biases inherent in the systems that create and use them (Kitchin, 2014), how they are subject to multiple (mis)interpretations (Pangrazio & Selwyn 2018), and how they can echo power relations in society (Van Wart, Lanouette & Parikh, 2020). In essence, data literacy justice must put equal emphasis on preparing learners to both "play the game" and "change the game" (Gutierrez, 2009), by both "reading" and "writing the world" (Gutstein, 2003; Gutstein, 2006).

While the goals of data literacy justice education are relatively established, *how* to approach these goals through the design of learning experiences is less clear. The contributions in this special issue build on the existing literature in mathematics and civics education, participatory design, arts-based methodologies, and culturally sustaining pedagogy. The authors explore new ways to support data literacy justice by enabling learners to choose how they engage with data in personally meaningful ways, and by examining how creative representation can involve audiences in learners' data work around social and political phenomena.

Below, we elaborate on three features common across the learning designs described in this issue: (1) Centering learners from historically marginalized populations in data work that extends from their lived experiences as individuals, and as members of their communities; (2) humanizing data through its creative representation, involving visual, embodied, and multimodal practices to reason about humanistic perspectives; and imagining new futures that integrate ethical and caring representations of their communities; (3) using socially situated data artifacts to "write the world." We then propose a way of mapping data literacy justice activities from data comprehension to participation, and from thin to thick justice.

2.1. Centering learners in data work of personal and social relevance

One of the ways that the contributions in this special issue address the goals of data literacy justice is in their explicit focus on social issues caused by, or made visible by data; and, in their active inclusion of members of the communities most impacted by those issues.

In Louie et al. (2022) for example, high school students from economically disadvantaged communities whose first language was not English, engaged in structured data investigations of income equality and immigration. The work demonstrates how educators can develop students' individual interests in data, their social and political consciousness, and their development of data literacy skills through combining real-world data from the U.S. Census Bureau with inquiry scaffolds directed at guiding sociopolitical investigations and discussions. For example, students investigated, "How much income inequality exists between males and females, and does education help to explain the gender wage gap?" and "Are immigrants less likely than U.S.-born individuals to participate in the labor force, before and after controlling for education?" Further, their work identifies how CODAP (Common Online Data Analysis Platform) supported the development of learners' data literacy skills during these investigations through access to person-level data, engagement in multivariable analysis, comparing measures of center, and working across various canonical data representations.

Meanwhile, Shapiro et al. (2022) explore an approach to building data science capacity among members of populations historically excluded from STEM through employment. They describe a program that employs participants as data workers, and trains them in basic data science competencies through work on data relevant to their local communities. Through data projects submitted by for- and non-profit organizations, participants

develop skills in data cleaning, formatting, and labeling, while also critically examining and representing issues that directly and personally impact them (in this case, data on policing within Black communities). Notably, the authors emphasize the importance of designing workplaces that actively promote the histories and perspectives of those systematically excluded and marginalized. They highlight the need to build data science knowledge upon learners' lived experiences, and encourage the use of intuitive multimodal, embodied approaches to sensemaking and communicating with data.

Similarly, in Kahn et al. (2022) high school students worked with local data from their community as they investigated the impact of the lottery in their communities. The work demonstrates the power of educational designs that scaffold learners to take a multimodal approach using mathematical, quantitative, and qualitative data reasoning. Coupling interviews with numerical data to understand social phenomena within a community promoted pluralistic perspectives rather than the monolithic views often used to frame minoritized communities. Learners found that individual reasons for playing the lottery ranged from addiction, to wanting to fund their children's education. Gathering various kinds of data from multiple sources allowed students to describe a holistic picture of the lottery's impact that accounted for the personal experiences of those implicated.

Arastoopour Irgens et al. (2022) go beyond learners' basic data science skills to support their reasoning about the uses of, and implications of emerging technologies in data science. Youth participants in an after-school program learned about algorithmic bias by making their own machine learning robots, and reflecting on how algorithmic bias in everyday technologies, such as facial recognition, can contribute to perpetuating larger scale racial and gender inequities. The work shows how youth can be centered in these explorations by giving them the capability to train their own algorithms, test them, and evaluate how and why they break down. By using these learner explorations as starting points, it provides them with first-hand experiences of how biased and faulty results can be programmed into these systems as they learn about data-driven computing systems in the real world.

These participatory approaches moreover build on learners' cultural values and interests to promote sustained engagement (DiSalvo & DesPortes, 2017; Druin, 2002). More specifically, they demonstrate the value of using learners' and their communities' own lived experiences as reflected in their focal data, as starting points for building the engagement necessary to develop comprehension, as well as the relatable contexts necessary to support critique. Notably, the contributions each demonstrate significant effort to develop communities of learners, within which guided discussion and shared experiences trust among members, developed through and through the valuing of participants' ideas, enables participants to freely and collaboratively explore otherwise difficult and sensitive issues around race and power (Vakil & Royston, 2019).

2.2. Humanizing data through creative representation

Another approach to fostering data literacy justice is in elevating emotion and embodiment through creative practices, which leverage multiple ways of knowing to communicate more effectively and equitably with data (D'Ignazio & Klein, 2020). In Kahn's et al. (2022) framework, Notice, Wonder, Feel, Act, and Reimagine, the authors highlight a procedure for integrating affect into one's approach to data. Three of the contributions in particular demonstrate how creating non-canonical representations engaged learners in new ways of sensemaking and communicating with data. For example, Bhargava et al. (2022) described how theatrical activities that allowed participants to embody statistical processes, such as binning (i.e., grouping data into categories), not only prompted learners' realization of how such processes can impact results, but also allowed both performers and audiences to relate to the stories of human experiences behind the data.

In Kahn et al. (2022) high school students, having calculated the minuscule chances of winning the lottery, used parody, analogies, and satire to communicate their findings, redesigning an existing lottery advertisement titled "Hey, You Never Know," to "Hey, Now You Know." The authors highlight how these rhetorical strategies were critical for learners to reimagine new futures for their community.

In Shapiro et al. (2022) data workers cleaned and explored a dataset on city policing activity through interactive visualizations, then created visual art to bring attention to aspects of their findings. Their design choices involved intentional decisions to humanize the data (e.g., plotting data points over a painted handprint, chosen to symbolize experiences in their own police encounters, such as in having fingerprints recorded during an arrest), what details to foreground (e.g., using black and red paint to distinguish the number of homicide-related arrests from other types of arrest); and what details to background (e.g., using aggregate neighborhood data to avoid drawing negative attention to particular neighborhoods).

As Philip Olivares-Pasillas and Rocha's (2016) study of visualization indicates, we cannot navigate authentic data without encountering issues of power that may reproduce and exemplify existing inequities. In each piece in this issue, these intersections are approached through creative visualization, bringing attention to the value of emphasizing alternative ways of representation, particularly those that center the contexts and people implicated in the data. Creative choices furthermore empowered learners to craft the messages they wanted to convey to the audiences they felt needed to receive them, thus giving agency to those directly impacted by the phenomena revealed in the data.

2.3. Writing the world with socially situated data artifacts

The learning experiences described in each of the contributions were notable in how they moved learners from critiquing data, to using data to take action toward just ends. One way that the contributions achieved this is through engaging audiences in sensemaking and advocacy, often by rethinking the relationships between form, medium and message.

For example, the data workers in Shapiro et al. (2022) created a publicly viewable video of their creative data visualizations of arrest data—juxtaposing their artwork with canonical data representations—to bring to light the disparate experiences between communities in their city, and to engage a broader audience in conversations around arrest data. The workshop participants in Bhargava et al. (2022) engaged in participatory theater, breaking down the typical barrier between performer and audience by inviting audience members to also perform, make meaning, and reflect alongside the performers. Similarly, Arastoopour et al. (2022) show how cooperative inquiry—a participatory design research approach that includes children in the design of their own learning experiences—with young learners facilitated them in rationalizing their choices to build algorithmic systems for particular purposes and users. Through their designs, children responded to the algorithmic bias embedded in many everyday technologies by embodying their own visions for more just applications of so-called helpful, data-driven technologies.

Together, these approaches demonstrate ways to support learners in acting to challenge the power structures with and within data practices; and in reimagining the structures, uses, and ownership of data (Khan et al., 2022). Resonant with the goals of culturally sustaining pedagogy, this approach goes beyond "How can 'we' get 'these' working-class kids of color to speak/write/be more like middle-class White ones" (Alim & Paris, 2017), to designing learning experiences that "perpetuate and foster—to sustain—linguistic, literate, and cultural pluralism as part of a schooling for positive social transformation" (Alim & Paris, 2017). At times such an orientation might involve participation in data work that emphasizes justice, and others, civic participation that draws on data knowledge. This perspective emphasizes that data-only approaches to exploring issues of justice can lead to exacerbation of inequities when data are used as the only or full story of an issue, or where data can be perceived to reify existing structures, rather than provide tools to challenge and construct structures through participatory action.

3. Directions for data literacy and social justice

Data literacy and justice are fundamentally interrelated, as each of the contributions to this special issue exemplifies. Further conceptual and empirical research is needed to conceptualize the key issues, tensions, and opportunities for learning at these intersections. Such insights will inform ways to support learning about, and toward, these interrelationships. Learners might bridge these domains by developing the cumulative knowledge and skills necessary for data justice: (1) Comprehension, that is, having an understanding the nature of data, and a fluency with manipulating it, (2) critique, which involves being aware of the sociocultural—and thus, non-neutral—nature of data, and noticing when data may represent, reify, and occlude issues of inequity and justice (D'Ignazio & Klein, 2020; Hardy et al., 2020), and (3) participation, which involves calling out and taking action on the biases inherent in the production and use of data, and advocating for social change. This special issue sits in a wider body of research on data literacy and justice both outside of, and within the field of education (particularly mathematics education). Here we draw together key lessons from this wider body of literature, and highlight areas for future development.

3.1. Thick and thin justice; data comprehension and data participation

Drawing on earlier work on thick and thin democratic education (e.g., Gandin & Apple, 2002; Carr, 2008; Zyngier, 2012), we suggest that one way to think about the intersection of data literacy and justice is through a thick and thin conception of justice. **Thin justice** foregrounds our participation as current or future members of justice or democratic activities and systems. This is what Westheimer and Kahne (2004) refer to as *personal responsibility models*, and which include paying taxes and obeying laws. **Thick justice** meanwhile seeks to promote participative action toward a deeper understanding of systems, not as given, but as shaped, shapeable, and critiqueable. This is what Westheimer and Kahne (2004) refer to as *justice-oriented models*, and which may include political organizing and lobbying.

In highlighting this spectrum, these researchers of democratic education emphasize that participation in society goes beyond knowledge of and participation in the structures "given," to shaping those structures through active democratic participation. This kind of participation is all the more important for tackling injustices and inequities reified in existing systems that can be challenging to tackle from within those systems. Through connecting thick justice to varieties of data literacy, we can highlight the potential to support learners in developing skills and knowledge such that through their comprehension, critique, and participation in and with data, they can write the world toward just ends.

In drawing this connection, we do not seek to make a value judgment regarding approaches taken; different approaches serve different purposes at different times for a range of audiences. Moreover, what might be described as relatively less critically engaged data literacy–what we describe as "comprehend," and has elsewhere been described in terms of reading the world–can serve to foster thick justice, in highlighting structures in society and how they change. In contrast, there are activities that involve data participation–the creation, critique, and engagement with data–that would not serve thick justice. This reflects the contextual nuance of these concerns, where features of the immediate micro (e.g., classroom, community center), meso (e.g., school, neighborhood), and macro (e.g., country, cross-nation), environment are likely to play important roles in interpreting actions and designing for justice learning.

Figure 1. A model of learning at the intersection of data literacy and justice
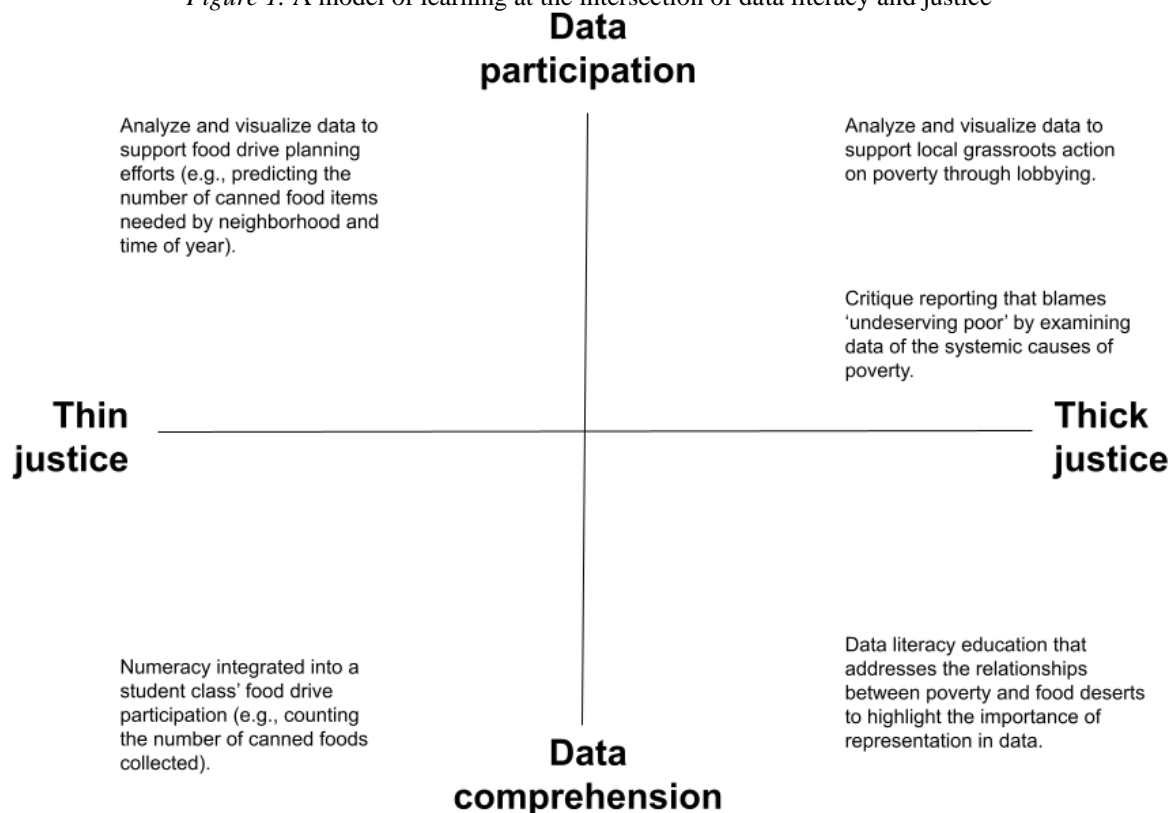
Drawing on the connections across these literatures, Figure 1 provides some indicative examples of how modes of thick and thin justice, and data literacy, may intersect in learning. Not captured in this matrix is the complexity of the content regarding key concepts, skills, and issues in both data and justice, ranging from the level of

statistical or visualization skill, to the capacity to navigate nuanced legal or historical contexts. Navigation of this key knowledge is challenging, with a recent systematic review of empirical research indicating that teachers experience tensions in curricula design at the intersection of mathematics content and social justice (Xenofontos et al., 2021). Models to help understand, and navigate, these sociopolitical and learning contexts are needed.

As in wider development of citizenship oriented learning, there is a balance to be found between (1) delivering on the content of democratic and justice oriented learning, with the requisite need to understand the key concepts and issues learning is targeting, and (2) the risk of focusing on knowledge delivery, providing understanding of content that will be used in later democratic participation. Charting this path requires a rich pedagogical approach for justice citizens that reflects local contextual features and curricula (Heggart, 2021). Charting the path of justice, and its connection to data, similarly requires consideration of these issues. Do we have a clear idea of what students should learn about, with, and through enacting, justice concepts? And are we clear about the pedagogical tensions and challenges inherent in teaching toward learning at these intersections of data literacy and justice?

3.2. Charting a path toward data literacy justice

The studies described in this issue offer rich examples with which to begin conceptualizing the relationships between data literacy and social justice education. They also highlight the need to ensure meaningful engagement with both domains, particularly given the range and complexity of skills and concepts to be taught and understood, from statistics and visualization, to socio-political and historical ideas.

Together, the contributions raise questions to be considered as the field continues to explore learning at the intersections of data literacy and social justice. For example: How can critical approaches to data literacy and justice, such as arts-based methods, amplify the efforts of existing social activist communities (Bhargava et al., 2022). How can we support learners in reimagining possibilities for data technologies that challenge and surmount the bounds of mainstream perspectives and beliefs (Khan et al., 2022)? Relatedly, how, in reimagining the use of data and data-driven technologies for social good, can we build on the roles and expertise of non-professional members of society (Arastoopour Irgens et al., 2022)? How can criticality be embedded in data work to complement, rather than counter, the business-oriented priorities of professional workplace settings (Shapiro et al., 2022)?

Key issues come to light in considering the need for greater prominence of data literacy and social justice in the preparation of young learners. For instance, how can curriculum design for data literacy justice integrate into the existing disciplinary structures of formal educational institutions, and moreover, build upon and reflect the local contextual features of learners' social environments (Heggart, 2021)? How can we prepare educators to support learners in the interdisciplinary space between data literacy and justice (Xenofontos et al., 2021), particularly given the need for both domain content and pedagogical expertise relevant to both domains (Parker, 2018)?

Further clarity on the pedagogical tensions at the intersections of data literacy and justice will inform the development of necessary curricular resources and design guidelines, assessment and evaluation, educator development, and data technologies to support teaching and learning. Such work must address the needs of both learners and educators across settings including professional learning, K-16 classrooms, and informal learning contexts, particularly those engaged with civic participation. Through this work, the field may gain the necessary insight to move learners from data comprehension in service of thin justice goals, to data participation toward thick justice goals.

Acknowledgement

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