Data storytelling in the classroom

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Data Storytelling in the Classroom

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Abstract: With the rising demand for data skills across industries and disciplines, and the prevalence of data in all aspects and levels of our lives, it is critical to find new, more effective ways to develop students' data literacies. Stories can be an accessible way for students to personally connect to, and think critically about, data and its implications. But how can data storytelling be effectively implemented into classroom settings, in which instruction is often constrained to focus narrowly on quantitative skills? This interactive poster session showcases eight innovations in data storytelling in the classroom. Together, the contributions consider the various facets and functions of stories for supporting data literacies in contexts that span K-12 to university. By seeking to define the value and roles of storytelling in data literacy learning, this session will inform ways to create more effective and engaging data literacy instruction.

Background and goals

The demand for data skills is rising rapidly across industries and disciplines (Bargagliotti et al., 2020). Recent reports call for early instruction in statistical thinking, probability and variability, and the process of inquiry (Franklin & Bargagliotti, 2020), and for attention to asking statistical questions, working with multiple data types, and building skills to communicate with and about data.

However, the pervasiveness of data in our social lives means that data literacies are not just useful preparation for the workforce, but also critical for making sense of complex cross-cutting issues, such as the

COVID-19 pandemic and climate change (Engel, 2017; Lee & Campbell, 2020). At the same time, classroom contexts pose numerous challenges to designers and educators who seek to promote students' data literacies. Constraints unique to the classroom, such as the need to adhere to subject standards, the limited time within a school day, and the compartmentalization of instruction to specific subjects, can focus data instruction narrowly on quantitative skills and tools. Ignoring the cross-disciplinary nature of data and the relevance of the social contexts of data limits opportunities for learners to use data for personally meaningful purposes, to address societal issues with data, and to critically examine how data is produced and used.

Stories are one way to engage students with the personal and societal impacts of data. Stories can serve as analytical tools, and for communicating both individual experiences and collective perspectives. By connecting personal, cultural and sociopolitical dimensions of data, stories offer opportunities to humanize data (Lee et al., 2021). This symposium explores innovations in data storytelling in classroom contexts. By showcasing curriculum designs and research insights from projects that span K-12 to university contexts, this symposium will examine opportunities to promote students' data literacy through storytelling and will critique the value added of stories over more conventional approaches to data literacy instruction.

What is the value of storytelling for promoting data literacies?

Stories have long been recognized as tools for sensemaking, identity building and empathy (Bruner, 1985, Cleto & Warman, 2019; Lind & Thomsen, 2018). Storytelling has moreover been mentioned in various ways in relation to data, including in fields such as science, data visualization (Park et al., 2021), and journalism (Matei & Hunter, 2021). It is also a more frequent topic in data literacy education. An informal search for the terms "storytelling," "data literacy," and "education," for example, returns 1320 results on Google Scholar, most, if not all, published after the year 2000.

However, definitions of *data story,* let alone of *story* more generally, vary. Some scholars define stories as a series of causally linked events, while others view it as goal-directed behavior toward resolving a problem, and still others define them in terms of specific components such as characters, settings, and plot (Stein, 1982). Meanwhile, in the context of science communication and data journalism, the term "data storytelling" has been defined as a narrative that offers a causal inference that counters audiences' assumptions (Matei & Hunter, 2021). Others write that good visual data storytelling draws an audience in, and helps to make data more persuasive, easier to understand, and to remember (Ma et al., 2011). Such claims about the value of data storytelling, however, remain largely under-explored (Liem et al, 2021).

In response to the increasing interest in data storytelling in education, this symposium seeks to approach a more robust understanding of the value of storytelling and of the roles that it can have in promoting data literacies in classroom settings.

Overview of contributions

Together, the 8 posters in this symposium demonstrate the various roles of storytelling in data literacy education. They show that stories can be used to contextualize and communicate about data in everyday life (Gebre); integrate different perspectives to represent and make sense of environmental events (Wagh et al.); critically engage with social inequities and stereotypes (Louie et al.); drive scientific exploration (St. Clair & Stephens); make sense of aberrant or unexpected data (Davidesco et al.), reflect on personal implications of data (Tes et al.); reframe sociopolitical crises (Rubel et al.); and identify personal connections to broader data patterns (Wei et al.).

A key theme across posters is that stories serve to humanize data, illuminating social contexts and individual perspectives. Stories are variously used as entry points into bigger ideas, invitations to inquiry, and analytic tools to make sense of data and relate to complex patterns and implications. Importantly, stories invite learners to draw upon various disciplinary practices and ways of thinking that move beyond STEM, including imagination, performance, visual expression, and writing. Together, these activities engage transdisciplinary data literacy practices such as prediction, interpretation, and communication.

Finally these posters identify and address challenges faced in implementing storytelling innovations in classroom settings, including the need to link topics to curriculum standards, and to ensure the authenticity of the different disciplinary practices involved in working with data within the structure of school.

Symposium format

Following introductory remarks by the session chairs, we will provide the audience with guiding questions, and will facilitate two rounds (4 posters each) of interaction among presenters and attendees. By

allowing co-presenters to also visit and interact with co-presenters, we seek to encourage rich discussions that cut across issues raised by their own and the audience's projects and experiences.

Following these rounds of interaction, two discussants will stimulate a broader conversation across presenters and attendees by offering reflections and insights from their unique perspectives: Amy Stornaiuolo, who studies youths' digital literacies and technology integration in schools; and Laurie Rubel, who studies the sociocultural contexts of mathematics education, with foci on data science and spatial justice.

This symposium will spark conversations about such questions as: What makes a data story a story? How is a data story different from an argument or an explanation? How can stories be used to promote data practices in meaningful and accessible ways to a broad range of learners? What challenges, opportunities, and strategies are relevant when incorporating data storytelling in classroom contexts? What kinds of support—technology-based or otherwise—benefit students and teachers in navigating their use of stories for data literacy? How can educators and learning designers leverage the affordances of stories to promote specific data literacies and practices? How can we support students' in moving from exploring data to producing a data story? Likewise, how can we support them in moving from an understanding of data situated in a story's context, to an understanding of the broader implications of data?

In answering these and other questions, educators and researchers will better know how to most effectively incorporate data storytelling into classroom settings to promote data literacies.

Descriptions of posters

1. Learning Design and Everyday Life as a Learning Context for Data Literacy
Engida Gebre

The increasing role of data in various aspects of our life prompted consistent calls for data literacy education. However, educational interventions are focused on developing technical competence and algorithmic aspects of data literacy thereby resulting in a narrow understanding of the concept (Gebre, 2018; Gould, 2017). In his critique of data literacy education practices, Mertala (2020) argued that the way we teach about data in schools is serving as a hidden curriculum for promoting data (il)literacy among students. This is because data is often framed as a "cognitive authority" and instructional practices focus on developing skill sets to deal with spreadsheets of data with limited connection to the role of data in everyday life. Addressing the disconnect between data literacy education and data practices of students in non-academic settings requires a situated data literacy education that considers students' everyday life as a learning context. That is, educators could design learning environments that involve storytelling with data where students learn with and about data as it relates to their everyday life and their communities.

In this proposal, we draw from our previous as well as newly started data literacy projects with secondary school students to a) develop learning design options that consider ways of using students' everyday life as a learning context for developing data literacy, and b) share students' work on storytelling and news reporting with data. More specifically, we build on the notion of learning as "active contextualization" (Gebre & Polman, 2020) and articulate learning design options where students consider the conceptual, competency and contextual aspects of data literacy. Using such an approach raises students' awareness about and understanding of data in everyday life thereby reducing what Brunton and Nissenbaum (2011) referred to as "epistemic asymmetry" related to data (il)literacy.

2 Investigating California Wildfires as a Site for Middle School Students to Engage in Data Practices & Modeling
Aditi Wagh, Engin Bumbacher, Adelmo Eloy, Jacob Wolf, Tamar Fuhrmann, Paulo Blikstein & Michelle Wilkerson

A central goal of science education is to support students in scientific sensemaking of real world phenomena. This often involves developing and evaluating models or representations of the phenomenon in conjunction with data about real world phenomena. The practices involved in coordinating between data and models in this process can offer productive opportunities for science learning (Blikstein, 2014; Fuhrmann et al., 2018; Georgens & Manz, 2021; Gouvea & Wagh, 2018). More research is needed to understand how to integrate these practices to foster science learning.

In this paper, we propose a conceptual framework that characterizes how students draw on different qualitative data and scientific modeling practices to answer a driving question. We draw on video data from a design-based research study on 8th grade students in California working on an inquiry-based unit on wildfires. They build computational models and analyze actual satellite videos to investigate mechanisms underlying smoke spread from wildfires in their state.

As a lived and shared experience, the California wildfires 2020 present a rich conceptual space for student sensemaking and storytelling (Bruner, 1991). We show that the process of coordinating data and models reflects elements of storytelling identified in our previous work (Wagh & Dickes, 2020) in three ways: (1) Students consider and reconcile competing perspectives as they try to integrate between different understandings of how wildfire smoke spreads from multiple sources (Ochs & Capps, 1996) such as their own lived experiences, their own and peers' scientific models (of the phenomenon) and their analysis of the data; (2) Students construct a theory of events along a temporal dimension as they interpret how successive events impact each other (Ochs & Capps, 1996), and position the models and data at different points along that dimension; and (3) As a class, students construct collaborative meaning through co-authorship, interpretation and multiple retellings of narrative events.

3 How Do Students Use Comics to Engage with Data?
Marian Tes, Kayla DesPortes, Megan Silander, Ralph Vacca, Camillia Matuk, Anna Amato & Peter J. Woods

Creative media provide opportunities to expand on the ways learners explore and find personal connections to data (Bhargava et al., 2015, D'Ignazio & Bhargava, 2016). As a form of creative media, comics offer a unique set of affordances for making sense of data (Bach et al., 2017). However, there is little if any research on how comics can activate young students' engagement with data, which would inform new ways of promoting data literacies in classrooms. This study asks: *How do students use comics to engage with data?*

We co-designed a unit with an art and a math teacher, who implemented it in their classrooms. In the math classroom, students (*N=33*) examined two datasets: (1) a national dataset from the Pew Research Center about teens' views of and experiences with friendships, social media, technology; and (2) students' own responses to a survey we designed asking about their friendships. Based on these data, we prepared boxplots, dotplots, and bar graphs. In their art class, students used the digital comic-making tool, Pixton, to communicate stories about friendship using inferences made from the graphs. We coded students' comics to identify: (a) data reasoning apparent in their comics (e.g., reflecting on one's relationship to the data, questioning the validity of data), and (b) whether data were intrinsically or extrinsically embedded in the narratives.

We found that comics that intrinsically embed data into narratives demonstrated nuanced engagement with data. Whereas some comics served simply as an alternative to reporting statistics (e.g., "You know only 47.8% of people think it's kinda easy to make friends?"), others integrated data in ways that advanced a plot. In one comic, for example, the main character reflects on being a part of the 21.7% of people who find it hard to make new friends, while simultaneously accepting an invitation to hang out with a prospective friend. This study demonstrates how comics can be an accessible way for students to engage with data, and can help teachers identify students' emerging data literacy practices.

4 Promoting Data Literacy Skills through Authentic Research Experiences in the High School Classroom
Ido Davidesco, Noah Glaser & Jimmy Naipaul

Data literacy is critical for students to make sense of complex societal issues, such as the COVID-19 pandemic and climate change. Yet, current K-12 curricula provide limited opportunities for students to engage in rich data practices by gathering, manipulating, analyzing, and visualizing data. BrainWaves was developed to support high school teachers in facilitating student-led neuroscience-inspired investigations. In this curriculum, students first learn about neurons, brain anatomy, and brain plasticity, and then, with support from science mentors, develop a research question of personal interest to them (e.g., how does listening to music affect learning), collect and analyze data, and share their findings at a culminating program symposium (Azeka et al., 2020).

This study explored the nature of student experiences analyzing and interpreting data in BrainWaves. We used a phenomenological methodology consisting of semi-structured interviews with program participants (37 students and 25 teachers). The analysis identified several key themes. First, students and teachers reported tension between having too much and not having enough data. Some students felt overwhelmed by the amount

of data and had difficulties seeing the big picture, while others felt that they did not have a sufficient amount of data to address their research question due to difficulties in the data collection process. Second, interpreting data, especially when it contradicted students' hypotheses, was a challenge, which often resulted in students focusing on aspects of the data that supported their hypotheses. Third, support and scaffolding from teachers and science mentors emerged as a key element in shaping students' experiences of working with data. These findings suggest that student-led research investigations can provide a rich context for students to develop their data literacy, yet sufficient scaffolding and structure are needed.

5 Grappling with data stories of social groups and social justice: A strategy for building interest in data literacy among historically marginalized youth
Josephine Louie, Beth Chance, Soma Roy, Emily Fagan & Jennifer Stiles

The world today is awash in data. Although data science is one of the fastest growing occupations in the U.S., historically marginalized groups such as Blacks and Latinos/as are greatly underrepresented (Priceonomics, 2017). To broaden participation in data science and to help all people thrive in a data-driven world, schools need new strategies to draw more diverse students to data literacy learning.

The *Strengthening Data Literacy across the Curriculum* project has been working on such a strategy. In line with Gutstein (2003) and Ladson-Billings (1995, 2014), the project developed prototype curriculum modules with a social justice focus to promote stronger statistical thinking and interest in data literacy among students from historically marginalized groups. In these modules, students use person-level data from the U.S. Census Bureau to articulate data stories (Pfannkuch et al., 2010) about whether and why group outcomes diverge. Using the online data visualization tool CODAP, students address questions such as: What have the incomes of higher- and lower-income earners looked like over time? What might explain the wage gap between males and females? How might we respond to a claim that immigrants are less likely than the U.S.-born to work?

Pre- and post-survey data from over 200 students in non-AP statistics classes from seven high schools with high proportions of Blacks and Latinos/as indicate that students who used the modules showed statistically significant growth in their interests in statistics and data analysis. Student focus groups and written reflections suggest that students found it engaging and meaningful to use multivariable data to wrestle with stories about real or purported inequalities among groups relevant to themselves and their families. Building students' abilities to tell data-based stories about social group outcomes requires interdisciplinary knowledge and skills, however, with implications for teacher training and professional development to support this learning approach.

6 Using data stories to motivate student exploration of science phenomena
Natalya St. Clair & Lynn Stephens

We want students to have the experience of learning science by doing science (Bell et al., 2005). Data stories can be used to frame guided inquiry so that students can use data they produce (Hardy et al., 2020) to communicate their thinking. In *InquirySpace 2: Broadening Access to Integrated Science Practices,* we frame curricular units with a phenomenon in which students produce data with sensors and then explore those data in an integrated data analysis environment. By developing a set of compatible technologies and approachable activities, students from many backgrounds may learn science by doing science—and communicate their findings with data.

In this exploratory case study, we visited a high school where half of the students are economically disadvantaged and a high proportion are minority students. A 9th grade biology teacher used the question, *Might having a fever affect your ability to digest dairy?* to motivate exploration of how temperature affects the reaction of milk and lactase. Using data she had collected with a glucose meter, one student interpreted the possible effect of several variables. When presenting to the class, the story she told of her data continued beyond the driving question, as she discussed where a lactase enzyme might be produced in the body and why. We consider which curricular and teacher supports may have helped motivate this student to expand on the story that was used to frame the inquiry.

7 Storytelling with Data in Response to Crisis: Shifting Away from 'Maths of the Morgue'

Laurie Rubel, Beth Herbel-Eisenmann Shiyan Jiang, Jennifer Kahn, Vivian Lim & Lee Melvin Peralta

Note on Authorship: This work represents the equal contributions of this writing group. Lead authorship is rotated on publication pieces; subsequent authors are listed alphabetically.

Storytelling in times of crisis–often told from the points of view of governments, corporations, and other institutional actors–typically showcases data using what we call "maths of the morgue" (Lim et al., under review). "Maths of the morgue" presents detached, disembodied, and unemotional views of crises, through visualizations that present an accounting of loss, using dehumanized quantities (e.g., fatalities, case numbers, unemployment rates). This form of storytelling benefits those in power by enabling governments, corporations, and institutional actors to exert and maintain influence over others with the effect that "maths of the morgue" becomes a technology of domination and control (Cisney & Morar, 2015). A "maths of the morgue" approach has become the default in K-16 education (Wilkerson & Polman, 2019), which increasingly emphasizes data and data visualization without adequately attending to the pivotal roles that emotion, action, and the imagination play in data (Kahn et al., under review). This approach to data storytelling in education neglects other possible liberatory functions for data storytelling like cultivating imagination and hope.

We present a reimagining of storytelling with data using a "maths of the living" approach, which draws on a synthesis of critical frameworks that attend to dimensions of power, race, gender and place (Data for Black Lives, n.d.; D'Ignazio & Klein, 2020; Loukissas, 2019). Our conception of "maths of the living" highlights the underappreciated capacity of data and data visualizations to embrace an animated view of life and personal experience; to embrace culture, history, power dynamics, ambiguity, and rule breaking; and to inspire action and shift our ethical orientations rather than representing the world from afar (Lim et al., under review). We formulate suggestions for learning designs that shift away from "maths of the morgue" towards our alternative of "maths of the living" and illustrate this shift using examples of storytelling with data.

8 Storytelling with Data in the Third Space: leveraging students' data literacies for scientific investigation and social change

Xinyu Wei, Cherise McBride & Michelle Wilkerson

The Storytelling with Data for Social Change workshop was designed to develop students' scientific data literacy through investigating, reorganizing, and reasoning the publicly available datasets on the Common Online Data Analysis Platform (CODAP). The workshop aimed to make data science education more accessible for middle school students from socioeconomically minoritized communities.

In partnership with the Lawrence Hall of Science, we recruited seventeen participants ranging from 12 to 14 years old. Participants were mostly from the Greater Bay Area, CA, USA, and from both dominant and non-dominant backgrounds. During five workshop sessions, students journeyed through a scaffolded introduction to the topic of environmental racism. They first read case studies and interviewed family members, then analyzed local datasets using CODAP to situate data patterns in terms of personal and historical contexts. Leveraging their repertoires of practice (Gutierrez & Rogoff, 2003), students used the Story Builder plug-in within CODAP (Wilkerson et al., 2021) or Google Slides to compose multimodal data stories and presented them on the course's last day.

We designed this workshop to be a third space (Gutierrez, 2008), whose curriculum is built on students' underlife (Goffman,1968; Gutierrez et al., 1995) to foster a co-constructed dialogic learning opportunity. We examined how people in different neighborhoods can be impacted by health hazards disproportionally, which inspired some students to investigate why some jobs are dominated by particular racial groups. For example, one 7th grade Latina student noticed the correlation between the dusty air and the frequent usage of eye drops by her father, a long-time construction worker. It prompted her to filter the asthma dataset and compare the mean number in her zip code to other nearby cities.

These stories position students' everyday practices and interests as grounds for expansive learning. They also demonstrate students' data literacies as sociological and historical practice, a frame that enriches data literacy in K-12 classrooms as culturally-sustaining, sociocritical, and ultimately supporting the construction of just social futures.

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