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Undisciplining environmental justice research with visual storytelling

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ABSTRACT

Environmental justice research has used maps to make visible the spatial correlations between hazardous waste disposal sites and poor and minority communities since the 1970s. No doubt, such visual evidence of marginalized communities disproportionately burdened with noxious facilities has been an important and powerful tool for activists, regulators, and educators. Despite the efficacy of such mappings in demonstrating unjust distributions of waste, critics argue that they do not capture the complicated processes behind this spatial phenomenon. In this paper, we discuss our pursuit of an "undisciplined" environmental justice project by using visualization, not solely as the traditional *product* of research, but also as a *process* for raising new lines of inquiry into the social and environmental dynamics at work in the landscape. To this end, we present one strategy we have used in our project to construct and creatively visualize a novel dataset on the transnational hazardous waste trade in North America. Specifically, we convened a one-day "Design Challenge" with geography students from several sub-disciplines. This event yielded new avenues for international environmental justice research on and visualization of the transnational waste trade, identified methods for and concerns about critical storytelling with large datasets, and highlighted the opportunities and challenges of using critical storytelling to undiscipline EJ research. The paper presents logistics leading up to the Design Challenge, key insights and critical discussion resulting from the day, and interviews conducted one year after the Design Challenge on enduring lessons from the process.

1. Introduction

Environmental justice (EJ) research and activism have historically relied on mapping as a visual representation of the uneven burdens of waste disposal and processing borne by marginalized communities. In particular, mapping has been an effective tool for illustrating the concentration of toxic materials in low income and minority neighborhoods (Margai, 2001; Higgs and Langford, 2009; Lara-Valencia et al., 2009; Raddatz and Mennis, 2013) and identifying clusters of high asthma or cancer rates associated with exposure to particulates (Buzzelli and Jerrett, 2003; McEntee and Ogneva-Himmelberger, 2008). In this paper, we build on this impressive body of scholarship by enacting an "undisciplined" approach to EJ research that unites diverse epistemological approaches around a specific problem. By undisciplined, we mean the collective and collaborative effort of applying diverse epistemological approaches, skill sets, and interests to one common problem or object in a way that expands avenues for investigation, rather than seeking consensus or converging on one answer to a pre-defined research question. It expands the emphasis on *product* in much EJ research (e.g., a map) to include the *process* of critical visualization. An undisciplined approach takes inspiration from work in geography and science and technology studies on collaboration (e.g., Star and Griesemer, 1989; Galison, 1997; Kitchen and Dodge, 2007), and we propose that it can be a particularly fruitful way of exploring novel datasets.

We apply this approach to an ongoing research project on the transnational hazardous waste[1] trade in North America. Despite its size and potential risks to public and environmental health, there are no readily available data regarding the impacts of the waste trade on specific localities or communities, making it nearly impossible to meaningfully visualize this trade and any attendant EJ concerns. We therefore assembled a dataset through a series of Freedom of Information Act (FOIA) requests to the United States Environmental Protection Agency (EPA) (Nost et al., 2017) Once these data were assembled, however, the stories that they could tell remained buried in and between the lines of the massive spreadsheet they populated. As is the case for the analysis and visualization of any dataset, big or small: the data simply cannot "speak for themselves."

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[1] Also referred to in this paper as "waste".

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As one strategy to decipher meaning in these data—and to facilitate an undisciplined conversation about EJ and visualization broadly—we convened a one day "Design Challenge" (DC) at the Cartography Lab at the University of Wisconsin – Madison. Participants came to the challenge with a range of experience, interests, and skills. Rather than being asked to use the dataset to answer a specific research question about EJ, participants were *instructed to find unique stories* in the data and given little further direction on how to proceed. Our focus, therefore, was not solely on using mapping and visualization as the traditional *product* of EJ research, but also as a *process* for raising new lines of inquiry into the social and environmental dynamics at work in the landscape. Given our interest in extending the DC as a method for "undisciplined" research, we also conducted a set of follow-up interviews with participants one year following the event to reflect on the experience. In what follows, we first discuss the use of mapping and visualization in EJ research and relevant issues in data visualization and visual storytelling. Next, we describe our case study, including the products of the DC event and the process of creating them. This leads us to discuss some of the tensions in critical storytelling with large datasets. We conclude by discussing opportunities and challenges of "undisciplining" research.

2. Undisciplining environmental justice through visualization

Environmental justice research has used maps to make visible and critique spatial correlations between hazardous waste disposal sites and poor and minority communities for decades (Berry, 1977; US GAO, 1983; Bullard, 1990). Thirty years ago, the 1987 United Church of Christ (UCC) report, "Toxic Wastes and Race in the United States," a landmark investigation into the geographic distribution of hazardous waste sites, found striking correlations at a zipcode level in United States Census data between racial minorities and the location of commercial, third-party facilities disposing of waste for profit.

Since the UCC report, EJ visualization has expanded to incorporate a range of spatial analyses that identify statistical relationships among the location of hazardous waste, the race or socioeconomic status of populations living near hazardous waste disposal and processing sites, and, when possible, their health outcomes (for reviews, see Bowen, 2002; Reed and George, 2011). Such studies generally involve three stages of research: (1) gathering data from public sources, such as the EPA's Toxic Release Inventory (TRI) of air, land, and water emissions of a variety of chemicals, (2) performing statistical analysis, and (3) visualizing results. Methods such as proximity analysis (i.e., buffering) and spatial coincidence are commonly used to make sense of these datasets (e.g., Lowry et al., 1995; Lovett et al., 1997; Sheppard et al., 1999; Verter and Kara, 2001; Maantay, 2002; Mennis, 2002; Kara and Verter, 2004; Mohai and Saha, 2007). Many EJ studies are therefore disciplined by a spatial analysis approach, documenting aggregated spatial clusters and correlations that may or may not be meaningful (Bullard et al., 2007; Mennis, 2002; Robbins et al., 2008). These studies are also disciplined in their use of separate and sequential steps that drive towards a *product*. While such products have proven useful for EJ research and activism, critical scholars have argued that environmental justice must also be understood as a structural—historical, contested, and spatially varied—process (Pulido, 1996, 2000, 2015; Holifield, 2004; Heiman, 1996) and that simply mapping contemporary geographic patterns or spatial correlations downplays the historical and political economic drivers of EJ issues (Pulido, 1996, 2000).

Our approach to mapping the hazardous waste trade uses modes of visualization common to EJ research in *products* that demonstrate problematic clusters and correlations, but also employs visualization as a *process* for raising *undisciplined* lines of inquiry that are not constrained to the original research questions or approach (Kitchin and Dodge, 2007). In this way, we argue that visualizations are not simply products that *work* for environmental justice and other geographic problems (MacEachren, 1995), but are always *at work*, shaping discourse and helping to forge research agendas. Our approach also aligns with calls to "undiscipline" cartography and visualization more generally (Crampton and Krygier, 2005: 12), wherein increasingly available mapping tools, combined with critiques of historically dominant mapping practices, "resist and challenge the received method and practice of mapping established when cartography became an academic discipline." For an undisciplined EJ, we argue that visualization as *process* offers the potential to illuminate the complexity of local and global drivers of uneven exposure to risk in ways including, but also moving beyond, traditional *products*.

This has special relevance given the challenges the data themselves often pose to EJ research. Many EJ analyses are also often hampered by inconsistent, outdated, or incomplete data (e.g., Maantay, 2002, 2007; Verter and Kara, 2001; Mennis, 2002; Maantay, 2007; Lowry et al., 1995; Kara and Verter, 2004; Lepawsky and McNabb, 2010). In response, some policymakers, academics, and activists claim that simply collecting more data will enable better "precision" in responses to health and risk disparities. Environmental sensors for air and water quality blanket the landscape, millions of health care records are collected daily, and gaps in authoritative data can be crowdsourced through citizens (Gandy, 1993; Goodchild, 2007; MacEachren et al., 2011; Leszczynski and Elwood, 2015; Tsou, 2015). At the time of writing, the EPA is initiating a switch from the annual paper-based reports we acquired through FOIA requests to real-time electronic reporting of hazardous waste transactions that it claims will facilitate this kind of data-driven action (EPA, 2016).

Yet, the recent rush to integrate such data into areas like environmental regulation has been critiqued from several perspectives. First, scholars have problematized the algorithmic mining and visualization of increasingly large datasets as "Positivism 2.0" (Muehlenhaus, 2014), since data large and small are a product of the interests and biases of its creators, and thus cannot "speak for themselves" (Gould, 1981; Haraway, 1988; Martin, 1991; Boyd and Crawford, 2012; Kitchin, 2014a,b). To counter such "naive empiricism" (Burns and Thatcher, 2015), some have called for "critical quantifications" that allow the complexities and erasures in the data to inform the approach to and meaning constructed from them (Thatcher et al., 2015). Such a critical quantification engages with the structural processes behind mapped clusters and correlations, enabling researchers to ask how the process of visualization privileges, obscures, and silences geographic actors.

One form that critical quantification can take is a storytelling approach, which has recently been taken up in cartography (e.g., Caquard, 2013; Robinson, 2011; Crampton et al., 2013; Muehlenhaus, 2014). A storytelling approach reinforces the role of small, curated datasets in EJ research (Burns and Thatcher, 2015), as a researcher must leverage his or her situated understanding to cull small stories from larger datasets. Such an approach enables researchers to humanize the data, bringing their own voice into the interpretation (Pearce, 2008; Kelly, 2015). A storytelling approach also emphasizes the importance of process over product in critical visualization. We argue here that the dialectic structuring and critique of unique narrative threads drawn from such data have the potential to support "undisciplined" exploration that drives enquiry in myriad directions, rather than research being constrained by one analytical framework or a specific set of canonical conventions (Crampton and Krygier, 2005). In our case study, which follows, we demonstrate how storytelling generates new insights about the waste landscape and environmental justice not only at the end of analysis, but during it (e.g., Lepawsky, 2016).

3. Methods

On Saturday, February 14th, 2015, geography students, faculty, staff, and visiting scholars crowded into the Cartography Lab at the University of Wisconsin – Madison for the first annual Design Challenge (DC). The DC was intended to be both a research strategy and a critical pedagogical experience, building on non-traditional approaches for

promoting creativity from the visualization community, such as student design competitions (e.g., Cartography and Geographic Information Society (CaGIS) and North American Cartographic Information Society (NACIS) student competitions), hack-a-thons or map-a-thons (e.g., Zook, 2012; Quinn and Yapa, 2016), and informal mapping meetups and workshops (e.g., GISCollective, MapTime). The DC also drew from several emerging practices for promoting creativity used in our cartography and geography curriculum, such as anchoring active learning in real-world problems and promoting collaborative learning environments (Roth, 2016). As an experiment in undisciplining EJ work, the DC focused on using visualization to break from "misconceptions", or problematic knowledge that students and researchers might bring to a learning context that can stifle creative and critical thinking (Fouberg, 2013). For the transnational hazardous waste trade, misconceptions may include expected spatial clusters and correlations; assumptions about the completeness accuracy and transparency of data and regulatory practice; among others. The DC drew 17 student participants in total: nine women and eight men comprising two PhD, four MSc, and six GIS Certificate students and five undergraduates from the UW – Madison. The participating students were supported throughout the day by two faculty, two staff, two visiting scholars, and two PhD student consultants, each of whom held relevant expertise in environmental justice and/or visualization.

As introduced above, *we challenged participants to visualize unique stories* from our constructed dataset on the transnational hazardous waste trade in North America. We gave them little instruction beyond this. The dataset contained information on transnational shipments of hazardous waste regulated by the EPA through the Resource Conservation and Recovery Act (RCRA) (Nost et al., 2017). The resulting dataset synthesized three main data sources: (1) import consent notice authorizations from the EPA to importers to US waste streams, (2) annual reports from companies exporting waste from the United States to Canada and/or Mexico, and (3) manifests documenting the nature, volume, and destination of each shipment of waste brought into the US. The dataset provided to participants included 21,184 import and export shipment entries (27% of what the final dataset totals). Each import entry contains up to 41 quantitative and qualitative attributes with 3370 unique possibilities and each export entry contains up to 29 quantitative and qualitative attributes with 3570 unique possibilities. The dataset covered US imports and exports from 2005–2012 with notable gaps and inconsistencies. Thus, the dataset was large, disparate, heterogeneous, and uncertain. We distributed the dataset and instructions for the DC to participants one week in advance of the event. We provided no ancillary data, expecting participants to seek out additional information as they needed it, and only suggesting potential sources (e.g., the US Census) upon request. Further, we did not attempt to gloss over uncertainties in the dataset. The dataset's sprawl, incompleteness, and ambiguities are exactly why we convened the DC; we hoped that multiple cuts through the data would enable a critical understanding of it.

The DC began with a group session in which we briefly introduced our research project in the context of environmental justice, outlined the format of the day, and fielded questions. Participants could work individually or in pairs and self-organized into 12 design teams (five two-person teams and seven individual projects). Participants designed for eight hours, with short check-ins every two hours to garner feedback from peers. All teams presented their work during a closing ceremony. Participants were afforded one additional week to integrate design feedback and resubmit the final product, with 10 teams submitting final designs. We offered $900 in prizes to award excellence in storytelling and design, with all participants receiving at least $10 and three meals for participation.

We also conducted follow up interviews with the participants one year after the event. Fourteen of the 17 student participants were available for an interview. We conducted nine semi-structured interviews in person and five by Skype. Interviews lasted from 30 to 60 min and explored the participants': (1) process during the event; (2) resulting understanding of EJ, including erasures and uncertainties in the dataset, (3) reflections on the prompt to find stories in the big dataset, and (4) reflections on the Design Challenge as a non-traditional learning experience. We recorded the interviews, which were then transcribed and coded according to key themes and tensions.

Table 1
Visual Stories from the Design Challenge. The Design Challenge resulted in ten final visual stories that focused on one of three overlapping themes: spatial distributions of waste at various scales (n = 5), (2) flows of waste between countries (n = 5), and (3) political-economic processes (n = 6). Each visual story represented new research questions for the project team.

Title	Theme (Scale)
Burying Hazardous Waste: Continental Imports to United States Landfills from 2007–2012	Flows (Transboundary)
Choose Your Own Hazmat Adventure Game	Political Economic
Detroit's Role in the Hazardous Waste Trade	Distribution of Risk (City)
Hazardous Waste Import Locations by Packing Group	Distribution of Risk (Country)
Hazardous Waste Treatment Facilities: The Communities	Political Economic Distribution of Risk (Country)
How one line on a map explains 9% of the US-Mexico Hazardous Waste Trade	Flows (Transnational), Political Economic
One Company and the North American Hazardous Waste Trade	Flows (Transnational) Political Economic
Solid Lead from Canada to the United States from 2007–2009	Flows (Regional)
Untitled	Distribution of Risk (State)
Ways we Eliminate Waste	Distribution of Risk (Country)

4. Results and discussion

The products from the DC represented original and creative visual stories that have since influenced our research regarding environmental justice. These visualizations and associated research trajectories can be broadly categorized as having three, non-mutually exclusive foci (Table 1): (1) uneven spatial distributions of risk at multiple scales (n = 5); (2) flows of waste between specific sites in different countries (n = 6); and (3) political economic processes (n = 6). Below we discuss these three themes and then turn to tensions around the processes used by participants in their visualizations.

4.1. Uneven spatial distributions of risk at multiple scales

Five teams visualized a waste attribute—the amount and/or type of waste—as unevenly distributed risk in the landscape. Each of these teams mapped risk distributions at a different geographic scale, embodying the prompt to find unique stories rather than assess aggregates. In some cases, teams linked the spatial distribution of waste with demographic data on race and income, but no team performed spatial statistics correlating them. Instead, each team investigated specific regional and local contexts. For instance, one participant used Detroit as a test of the traditional EJ assumptions that poor and minority neighborhoods are disproportionately burdened with waste disposal and processing facilities (Fig. 1). Through a visual assessment, she found that facilities tended to be located in a variety of neighborhoods (white, non-white, and mixed-race) as defined by census tracts. In contrast, a second participant examined the uneven burden of risk at the scale of zip codes in a slideshow of maps, and did find visual relationships between waste treatment facilities and community rates of educational attainment and unemployment. The Detroit area stood out with the highest unemployment rate among communities with a treatment facility (Fig. 2). Taken together, these visual stories call into question the appropriate scale(s) of analysis for environmental justice research (e.g., Fisher et al., 2006), and suggest that race and class as

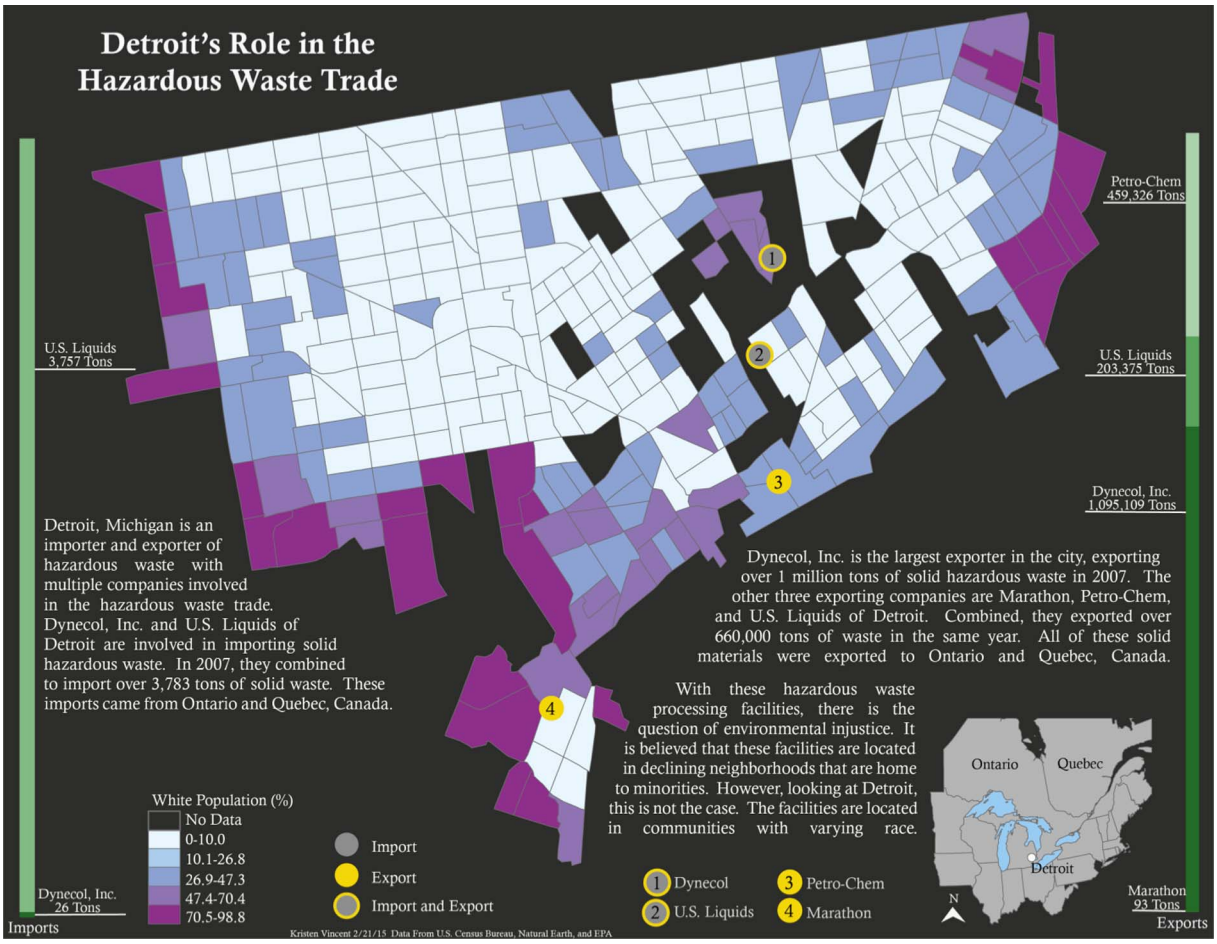

Fig. 1. Detroit's Role in the Hazardous Waste Trade. This visualization examines the transnational hazardous waste trade in the US City of Detroit, identifying four treatment facilities that import and/or export waste to and from Canada (as symbolized by the stroke and fill of the numbered point symbols). The visual story identifies Dynecol, Inc., as the main industry player within the city limits. The treatment facilities are mapped against the percentage of white population at a Census tract level (lighter shades indicate a higher percentage of non-white residents, while darker shades indicate a higher percentage of white residents), suggesting no clear visual relationship between the location of facilities and race in Detroit. (image courtesy of Kristen Vincent).

static categories might not be the only relevant factors to explore when evaluating the differential distribution of risks across communities (e.g., Pulido, 2000). Overall, visual stories highlighting the spatial unevenness of risk raised new questions about how places vary in their experience with the trade.

4.2. Transnational flows

Half of the teams mapped flows of waste between specific import and export sites in different countries. Flow mapping grapples with the dynamics through which specific types of wastes arrive in specific communities, offering insight into the evolution of unevenly distributed pathways and attendant burdens of hazardous waste processing and deposition. As with the uneven spatial distributions of risk, students mapped transnational flows at different scales and regions, again providing insight into the regional and local contexts of flows. One team examined the Great Lakes region, demonstrating how the trade in solid lead waste was concentrated around Lake Erie, with most importers located in Michigan and Ohio and exporters in Ontario (Fig. 3). Seeing these flows of solid lead waste raised questions for future research into how physical properties of any kind of waste may shape the geography of its disposal. Another team focused specifically on borders, visualizing the communities that function as chokepoints for waste's entry into the western US and tracking the waste from entry to deposition (Fig. 4; Slides 1–9). Through their multiple maps, the team demonstrated that hazardous waste imports enter the western US through a small set of border crossings and terminate at a small subset of landfills, despite being spread across numerous processing facilities in between. The team enriched the story by drawing on contextual information to frame how the landfills were developed and their impacts on local communities, including how one community fought against the landfill (Fig. 4; Slides 10–15). Overall, these visualizations of the flows of hazardous waste raised new questions about the local and regional drivers and impacts of the transnational waste trade, directing us to pursue future work on the historic link between exporting and importing sites, border regulations, and the growth of subnational waste havens for specific hazardous materials.

4.3. Political economic processes

Four teams visualized the political and economic processes underlying transnational flows of hazardous waste. For instance, two teams noted that a significant portion of the trade is handled by just a few companies. Their maps, illustrating the corporate consolidation of the waste trade, attempted to respond to the representational challenges posed by critical approaches to environmental justice by highlighting economic processes. One team found that Clean Harbors Inc. accounts for around 40% of all shipments, most of which are made between facilities it owns in the US and Canada (Fig. 5). A second team was able to distill nine percent of *all* flows to a single shipping route of vinyl chloride between Mexico and the US, using contextual information to conclude that "Low transport costs plus NAFTA equals a booming trade

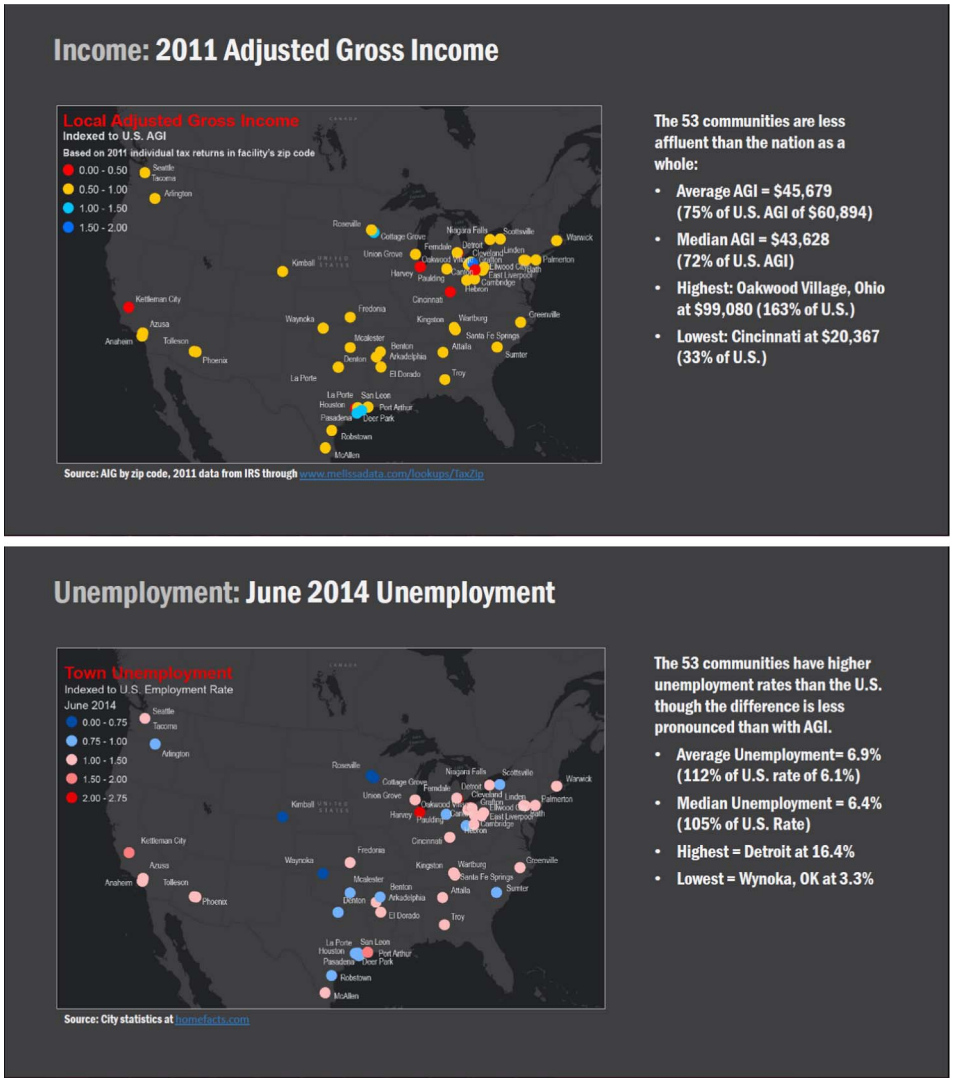

Fig. 2. Excerpts from Hazardous Waste Treatment Facilities: The Communities. This slideshow examines the uneven distribution of hazardous waste import facilities according to a range of demographic and socioeconomic factors aggregated at zip code regions. Two visualizations from the story revealed a particular unevenness across the 53 communities receiving waste. **Above**: The majority of communities receiving hazardous waste fall below the 2011 national average for adjusted gross income (as symbolized by warm reds and yellows), with the Cincinnati area having the lowest aggregate AGI among receiving communities in the dataset. **Below:** While not as prominent as AGI, the majority of communities receiving hazardous waste fall below the 2014 national unemployment rate average, with Detroit having the highest unemployment rate among receiving communities in the dataset. Combined with Fig. 1, these visual stories suggest that risk burden in Detroit may be driven more by unemployment than race compared to other US communities, and call into question the appropriate scale(s) of analysis for understanding the transnational hazardous waste trade (image courtesy of Dean Olsen).

in hazardous waste between Mexico and the US" (Fig. 6). Even if they make no explicit connections between consolidation and environmental justice at specific sites, these maps raise questions about the power dynamics that shape where firms locate processing facilities and the effects this has on the kinds of waste entering such communities.

Finally, one participant used hand-drawn cartooning to create the beginnings of a "choose your own adventure" game, in which players adopt the perspective of a stakeholder in the hazardous waste industry, each having a different set of incentives and risk regarding their participation. Her visualizations (Fig. 7) aimed to consider, "how [waste] affects the people who interact with it, how it affects the industry itself." This participant demonstrated how much of environmental injustice is the result of structural processes driving the industry and differential opportunities for people working in it (Pulido, 2000; cf. Pulido, 2015).

Overall, teams that grappled with the political economic processes behind the transnational hazardous waste trade used provocative but very different design styles to engender different affective responses to their visual stories about the political economy of transnational hazardous waste. Such visualizations, therefore, allowed participants to discover the "very scary" scope of the hazardous waste trade, as well as the predominance of only a handful of companies in it. As one participant stated, "I was really surprised how much, how big [the transnational hazardous waste trade] is and that [companies] are really making money off of this." Two additional participants explicitly expressed surprise, while another recalled: "going through the data and seeing these flows and just how much money is in some things like this dirty waste. In our case we looked at lead and it's something … that's really hurting people." Another participant was more indignant: "[companies] still feel that they can just like push[waste] out of one place and just dump it somewhere else … and … there are the people living there and people being affected by that." In addition to creating visualizations with unique and vivid styles, interviews thus revealed that participants were engaged with the question of EJ at an affective as well as an intellectual level.

The hazardous waste trade among the countries of North America is indeed significant in terms of both the quantity of waste and the quantity of profits, facts that helped make the DC effective across

Fig. 3. Solid Lead from Canada to the United States from 2007–2009. This visualization illustrates the volume of flows in lead between Canada and the US. Here, the size of the flow line at the arrow is scaled in proportion to amount of lead by weight moving between sites. Seeing how the flows of lead are isolated in the Great Lakes region forced us to consider the way that the physical properties of any kind of waste may shape the geography of its disposal (image courtesy *Gillian Cooper and Clare Trainor*).

disciplinary interests and even when participants had little background knowledge with hazardous waste or EJ per se. One participant reported his surprise at just how much waste was imported into the US, "Seeing big numbers and then being like, how much? Is that in pounds? Oh my god." The scope of the trade makes it imperative to find multiple avenues through which to research it, while emphasizing that, as one student put it, "all these issues are social justice issues and that it is really uneven who's affected by these things." One participant, for whom the DC was their first exposure to EJ, echoed this sentiment after working with the dataset: "I hadn't really known about transfer of waste before, so it definitely made me realize the inequalities. Where the waste was going and who it was affecting and the social injustice of that." While the trade's surprising scope and the potential for unjust distributions of waste were interests shared across participants, the process through which groups visualized their findings diverged, highlighting two interrelated tensions in using events like the DC as a method for making sense of large datasets.

4.4. Naive ethics? Trust and data visualization

One tension that divided participants was their level of trust in the dataset and the visualizations they created during the DC. Trust is particularly important in an environmental justice and waste regulation context, where visualization is used both to reinforce and undermine the status quo. The size of the dataset further complicated the perceived trust in the visual stories; as one participant remembered, "one thing I learned from the other folks is just because there are a lot of entries, it does not mean [the data are] more accurate." Indeed, interview participants were split seven-to-seven when asked if they trusted the dataset and visualizations. Participants recalled a range of uncertainties that negatively impacted their design process and trust in the data (Table 2), an issue list that has proved extremely valuable to our subsequent analyses of transnational flows of hazardous waste.

Many participants also reflected on what the uncertainties in the data meant for EJ. They reported shock at the lack of knowledge about, and oversight of, the transnational hazardous waste trade, whether they felt that this was accidental or part of a more intentional effort on the part of the government or corporations. For example, one participant stated "it was surprising to see the government doesn't know where all the stuff is going," while a second commented on the human error involved in data collection: "I thought the EPA or whoever was collecting this … would have been much more, I guess, comprehensive than it turns out that they are." Another participant reasoned that the collecting agency, as part of the US government, made things difficult: "… because usually governments don't want you to know things, you know." For a fifth participant, problems with the data reflected a lack of will, but not malice (cf. Pulido, 2000, 2015). He believed, "nobody cared enough about transnational waste to make and actually build the database about it … It was … clothed not in secrecy but just obscurity." Others, though, thought the secrecy willful on the part of companies that, "didn't want the general public knowing about, probably, the hazardous waste moving around. These companies don't want people knowing what they are doing that much …" Regardless of whether they ultimately trusted the dataset, it was clear that the DC promoted critical quantification and helped participants move past a naive notion of the role data play in environmental justice.

4.5. Naive empiricism? Directed storytelling vs. undirected storyseeking

Perhaps the most significant tension related to the process participants employed to identify stories in the dataset. Participants fell into one of two camps. Five performed what we describe as *directed storytelling*, in which they came to the DC with a clear topic in mind and sought evidence from the dataset to support their narrative arc. These directed storytellers conducted background research on hazardous waste and environmental justice before diving into the dataset. Directed storytellers relied less exclusively on the dataset we provided and more on other context information, drawing from sources such as the US Census' American Community Survey, the National Salary Trend Tool, and materials safety violations from the Federal Motor Carrier

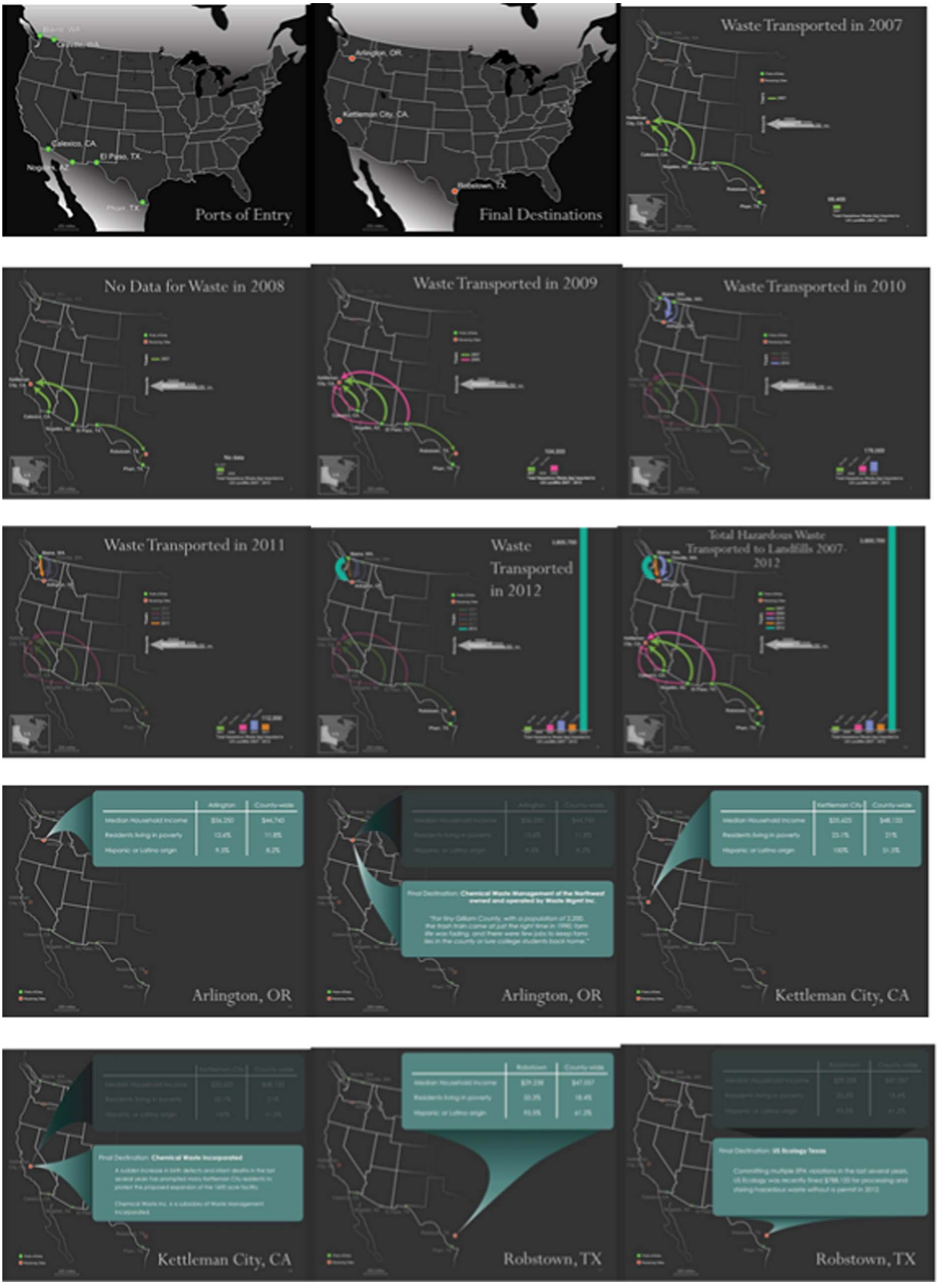

Fig. 4. Excerpts from Burying Hazardous Waste. This slideshow examines the chokepoints hazardous waste flows into the US. Despite the broad network of processing plants in the US, most waste in the western US enters as a small set of border crossings (Slide 1) and is deposited in a small set of landfills (Slide 2). Slides 3–9 demonstrate the origin-destination movement of waste through time in a set of small multiple flow maps. Slides 10–15 then enrich the story using context information to inform how the landfill destinations were developed and what their impact is on the local community (positive and negative). Every flow route and each landfill has a unique story (image courtesy of Constanza Bravo and Michelle Hu).

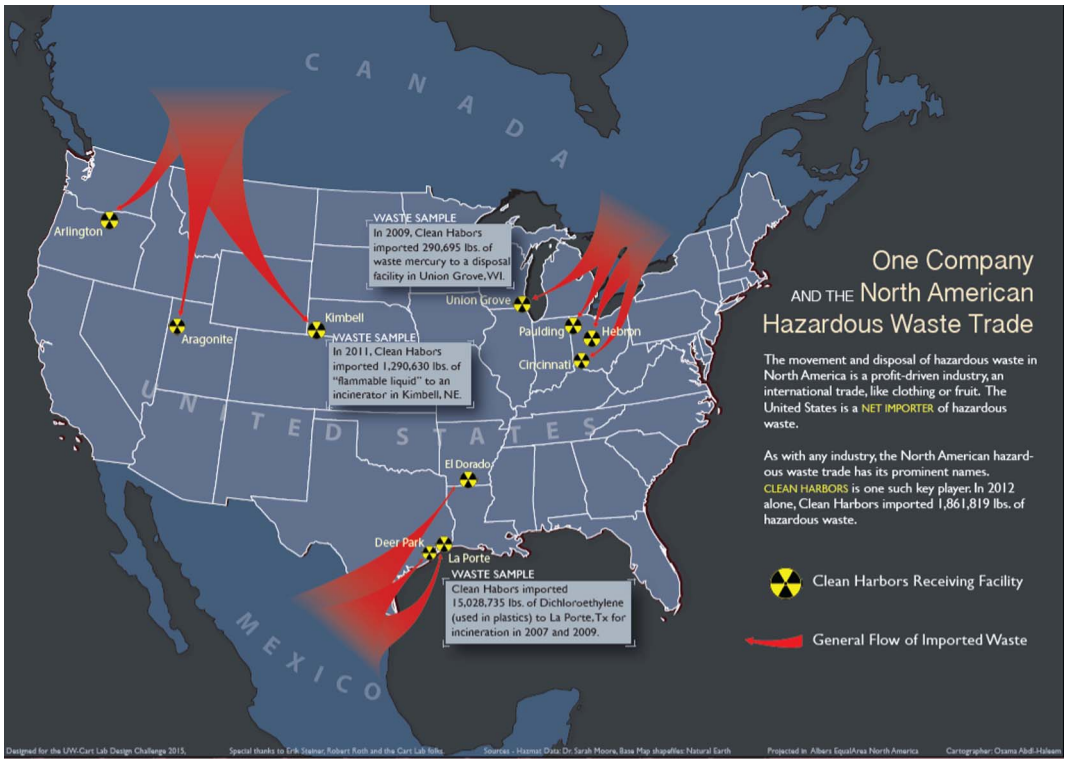

Fig. 5. One Company and the North American Hazardous Waste Trade. This visualization examines the influence that one company, Clean Harbors, has over the transnational trade of hazardous waste. Interesting, the majority of Clean Harbors transactions is between its own subsidiaries. This map makes use of a sensationalist visual style to call attention to the wide geographic distribution of Clean Harbors plants in the US, telling the story of the size of this industry and its primary political economic actor (image courtesy of Osama Abdl Haleem).

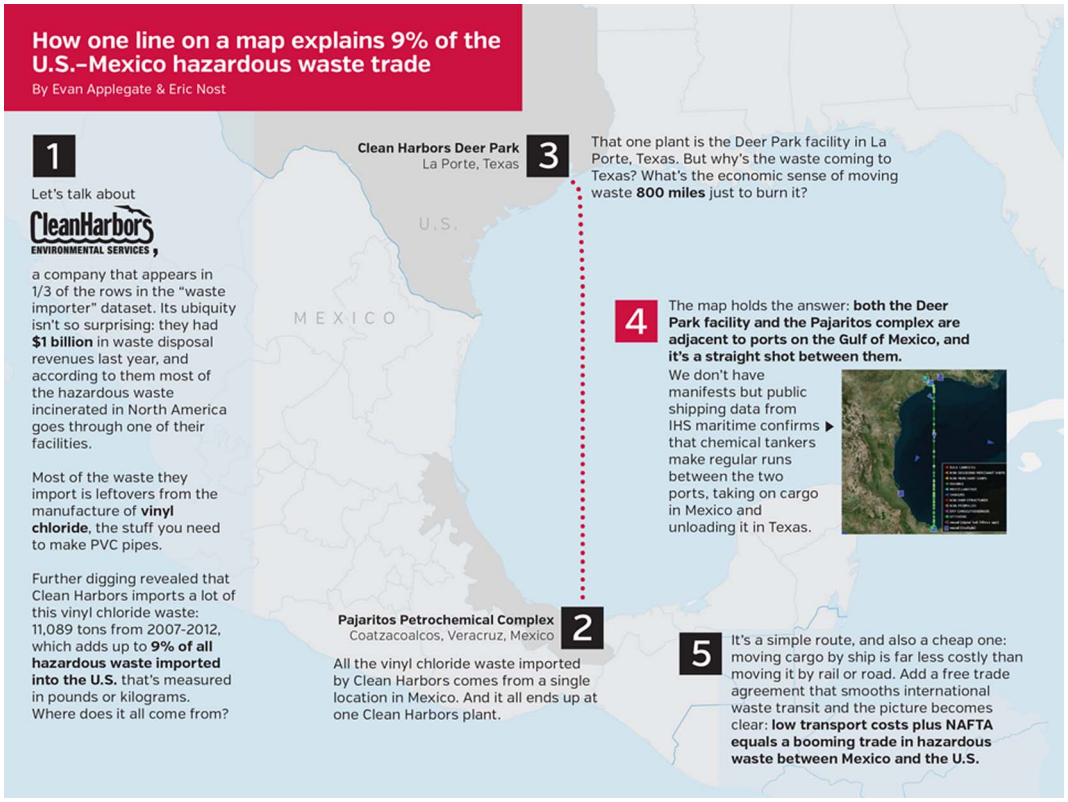

Fig. 6. How One Line on a Map Explains 9% of the U.S.-Mexico Hazardous Waste Trade. This visualization examines a single shipping route for vinyl chloride. Remarkably, the movement of vinyl chloride between the Pajaritos Petrochemical Complex and Clean Harbors Deer Park constitutes approximately 9% of all transactions in the dataset. Geography appears to be central to the story, as the straight-shot water route provides a cost-effective mode of transport. This map makes use of an authoritative visual style to present data-driven evidence as fact, a practice common in data journalism (image courtesy of Evan Applegate and Eric Nost).

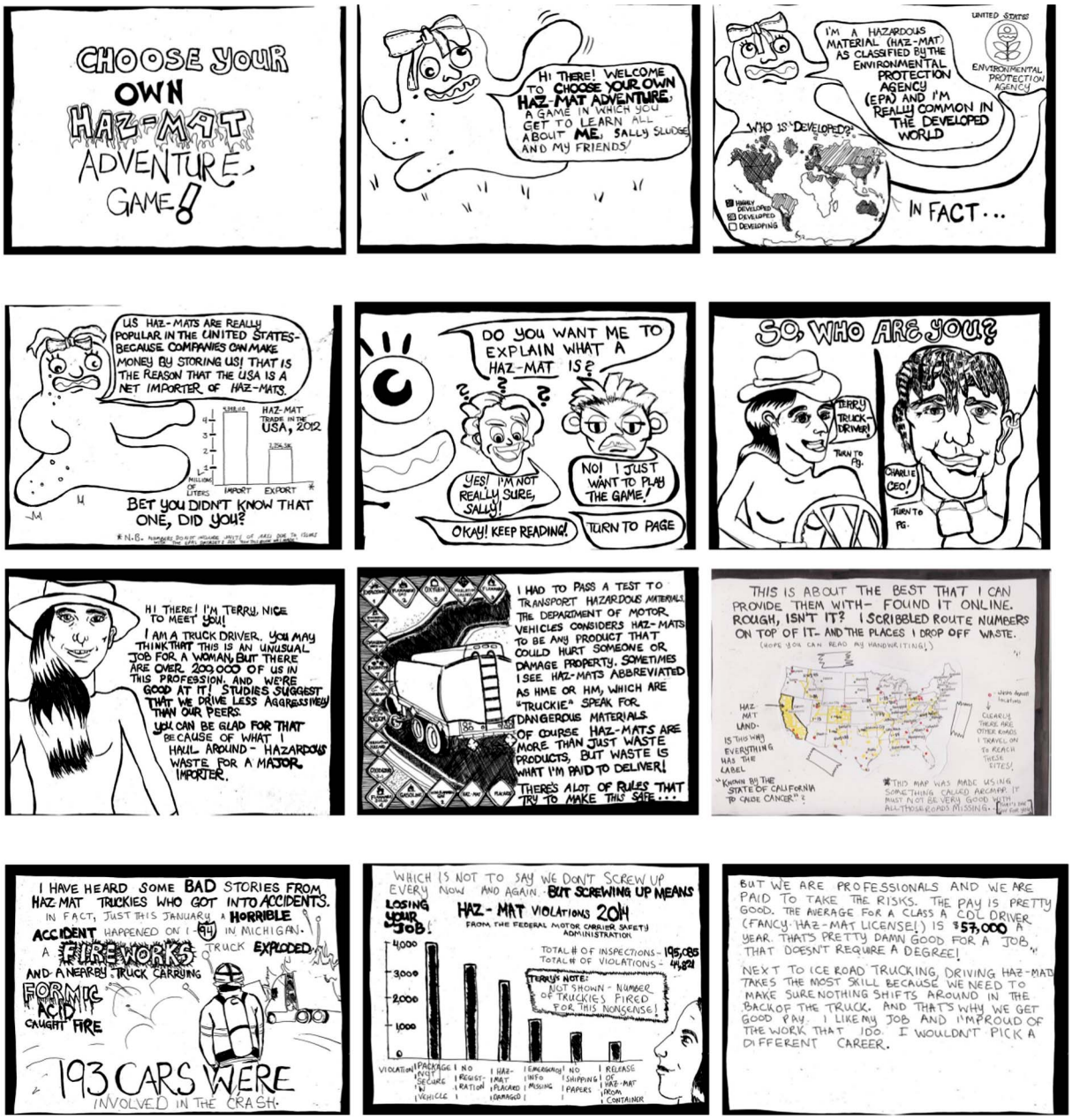

Fig. 7. Excerpts from Choose Your Own Hazmat Adventure Game. This choose-you-own-adventure visual story unfolds the complex and unfamiliar hazardous waste industry through narration from multiple stakeholder perspectives. Six perspectives are developed through extensive background research on the industry (two of which are shown on Slide 6), each having a different set of incentives and risks regarding their participation (or lack thereof) in the waste trade. Slides 7–12 walk through one of these perspectives: A truck driver requiring specialized training to safely move hazardous waste through the landscape, A hand-drawn, cartoon visual style is used to humanize the dataset and evoke the voice of the real people impacted by the transnational trade of hazardous waste (image courtesy of Chelsea Nestel).

Safety Administration. As one directed storyteller stated "most of the information I presented was not part of the dataset that was provided to me", while a second explained "I would take what I could from the dataset and then, if I couldn't find the answer from the dataset, which sometimes happened, I looked for other data."

In contrast, nine of the interview participants performed the process of *undirected storyseeking* in which they mined the dataset for relevant threads and drew on limited outside context. As one undirected storyseeker exclaimed, "You give me a spreadsheet, I'll find the story," while a second said he used the morning of the DC to "let [his] creative juices flow." To identify threads in the dataset, seven undirected storyseekers searched for regional clusters in the import and processing of waste, three searched for unique outliers in imports or exports, and three searched for visual correlations between trade volume and proxies of marginalization used in environmental justice. Notably, three of the directed storytellers switched to the process of undirected storyseeking because they could not find evidence in the dataset that supported their original idea within the DC timeframe. As one of these participants explained, "there's no story if there's no data".

Despite this split, most participants saw advantages and limitations to both approaches to finding stories. Several participants shared concerns over their undirected storyseeking, echoing the "naive empiricism" critique of the idea that data can "speak for themselves." They were concerned about finding relationships or stories that were not "real". One participant reflected that he/she, "saw people messing around with data and trying to create stories out of it. Whether those stories were appropriate to the data or to the task at hand was rather up in the air," while a second concerned participant thought that, "having a big dataset was just inducement to dig out its spurious correlations." However, the directed storytelling approach also drew criticism, as

Table 2
Uncertainty and Trust. Interview participants discussed a number of uncertainties in the dataset that impeded their design process, ultimately shaking the trust of some in their resulting visualization. The discussion of issues in the dataset has since helped us better consider issues of regulation and governance as we move forward with deeper analysis of waste regulation and environmental justice.

Type of uncertainty	Frequency
Incompleteness	
Missing or under-reported shipments	7
Missing geocoded coordinates	1
Missing units	1
Inconsistency	
Inconsistent units	8
Inconsistent waste codes/names	5
Inaccuracy	
Geocoding errors	3
Misspelling	1
Imprecision	
Geocoding imprecision	1
Aggregation resolution	1
Rounding	1
Lineage	
Handwriting/transcription issues	3

preconceptions and bias can lead to a story that "is in fact being spun." Critics noted how easy it was to find what they wanted to find in the dataset. As one participant claimed about directed storytelling, "You could go dig around for the numbers that support what you think you're gonna find and you'll probably find them because it's hard to sort out." Participants did offer positive sentiment that undirected exploration of big datasets is important and useful, with one stating that, "There is this large amount of data and you can't just ignore it. As a designer you have to be able to adapt to it and be able to understand what's in the data."

Participants further reflected on potential solutions to the limits of both undirected and directed storytelling. One participant stated that it may be more useful in undirected storyseeking "to think in terms of cases rather than exploration," with the goal of presenting unique case studies, rather than generating new insights about broad patterns. Regarding directed storytelling, several participants noted the value of cultivating multiple perspectives, with one participant stating that "it is okay to be subjective and creative … I don't think that subjectivity is always bad" and a second adding, "the value of the DC was to show that you can address a dataset – a ridiculous dataset, a ridiculous problem – with lots of different maps coming at it from lots of different angles." Cultivating multiple perspectives required collaboration. As one participant stated, working with a partner and presenting findings to the group helped them to avoid "telling a lie" by only using data that supported their claims, while a second reflected on prior professional experience, stating that "I've done this kind of thing before … we're handed a big ugly spreadsheet and told, 'pan for gold', and so it was just all pretty familiar. I guess what I learned is peer advice helps because I'm always looking at the big spreadsheets alone." Thus, the collaborative component of the DC encouraged participants to grapple with the ethical dimensions of coaxing stories from a complex dataset.

5. Conclusion

Critical environmental justice scholarship seeks to explain why and how minorities are differentially exposed to hazards (Pulido, 1996; Maantay, 2002; Mohai and Saha, 2007), and expands the environmental justice framework beyond the US (e.g., Carruthers, 2008). These advancements suggest a need to move beyond maps demonstrating spatial correlation, still a dominant approach in EJ (Reed and George, 2011). The DC as a process and event was successful in helping us to creatively visualize slices of the big dataset and identify compelling stories that might provide new roads for an ongoing critical EJ research project related to the transnational hazardous waste trade in North America. Many participants in the DC, without prompting, encountered these challenges and overcame them in creative ways by highlighting uneven distributions of imported waste across scales, mapping transnational flows of hazardous materials, and exploring political economic processes like corporate consolidation and structural environmental racism, giving the research team new avenues for exploration of a big data set. These results supported our focus on visualization as a *process* for raising *undisciplined* lines of inquiry that are always *at work*, helping to forge research agendas with the potential to illuminate the complexity of local and global drivers of uneven exposure to risk in ways including, but also moving beyond, traditional *products*.

Our case study also revealed some of the tensions inherent in undisciplining EJ. Students were split in the forms of trust they were willing to cede to the data. Most notably, they provided different explanations for absences in the dataset. But even in this difference, students grasped that data cannot be blindly trusted - students moved past a naive faith in data and its ability to inform policy and activism. Second, some students sought to find the story they wanted to tell, while others were more interested in letting the data speak to them. The latter did not do this uncritically. Students were aware that they might find "spurious correlations" and they sought out case studies rather than broad insights. The former, the directed storytellers, realized the limitation of a singular, intentional cut at the data and grasped the value of cultivating multiple perspectives through collaboration.

In short, while many participants came into the DC focused on strengthening skills and knowledge in their own specialty area, our follow up interviews revealed the attainment of critical quantification concepts in data visualization and EJ across the group. The undisciplining of the EJ project, therefore, was achieved, *not* by cross-disciplinary training per se (as in each student on his or her own is now able to operate across geographic subfields), but in the collective and collaborative effort of applying diverse epistemological approaches and skill sets to one common problem.

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