

What Do You Meme? Students Communicating their Experiences, Intuitions, and Biases Surrounding Data Through Memes

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ABSTRACT

Memes have become ubiquitous artifacts of contemporary digital culture that integrate visual and textual components in order to communicate about a topic. They can be used as forms of visual argumentation that draw on cultural references while facilitating critical commentary that typically results in humorous and caustic dialogue. In this paper, we investigate the meme creation tool, DataMeme where middle school students explore graphs then construct GIFs using existing Giphy GIFs and overlay their own text onto them in order to communicate about the meaning behind the data. We explore the ways the students engaged in data reasoning and their argumentation practices as they communicate through their memes. Findings from our analysis of 56 data memes and the corresponding written explanations from the students, show that data memes allow students to evaluate data claims within their broader societal implications, while also expressing personal beliefs and attitudes about data.

CCS CONCEPTS

• Human-centered computing → Visualization; • Applied computing → Computer-assisted instruction; Media arts.

KEYWORDS

data literacy, argumentation, memes, arts education, data reasoning, middle school classrooms

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1 INTRODUCTION

Data literacy is an important competency for individuals in our society. Much of the population consumes news and media that leverages data, and is also faced with making informed decisions about various facets of their life in which data is central; for example, in their decisions about finances, home ownership, and healthcare. Data literacy goes beyond mathematical and statistical literacy, and encompasses an inquiry process in which learners explore the contextual components of data as they engage in reading, analyzing, making decisions around, communicating about, forming arguments with, and being critical of data [10, 62]. Importantly, individuals must be able to integrate their understanding of data into their understanding of the topic of the data. One way to do this is through ensuring that learning environments provide a focus on the context beyond the numbers.

Researchers have found that using context to ground mathematical concepts can be important for learners to practically apply their knowledge to the real world, and to promote engagement by building on learners' interests [9, 22, 28]. Further, D'ignazio and Klein [11] argue for the necessity of context stating, "data are not neutral or objective. They are the products of unequal social relations, and this context is essential for conducting accurate, ethical analysis." However, researchers have also identified challenges with integrating context into students exploration of data. Wild et al. [59] argue that that context can create complexities if introduced at the same time as learners are building their other mathematical competencies, and therefore, it could be beneficial to limit the various aspects of the data that learners have to deal with at once. Additionally, it can be difficult for learners to tease apart the data,

its implications, and their own biases around it. Our investigation explores how we might leverage technology to address some of the challenges of integrating context within a data investigation. Specifically, we examine the ways in which a tool called DataMeme can support learners in communicating about their *experiences, intuitions, and biases* surrounding data through the (potentially) culturally relevant and multi-modal medium of memes.

Memes present visual and textual elements to convey narratives about data [51]. They can be powerful visual argumentation artifacts in contemporary digital culture. In large part due to their ability to effectively articulate values [51], memes can influence attitudes and behaviors [48, 50], and help to challenge and/or reinforce hegemonic ideals [56]. The use of memes offer an under explored opportunity for students to engage in reasoning about data and connections to their own cultures and values. In this work, we examine how students' process of constructing data memes can support their data reasoning and data argumentation, while showing how learners initially interpret, understand, and contextualize data. We believe the potential for DataMeme is not to evaluate students' data literacies, but to offer sites for, and windows into, students' critical reasoning about data.

This work is part of a larger cross-curricular co-design project called Data Literacy Through the Arts (DLTA) [13]. Within the project researchers work collaboratively with middle school teachers to co-design curriculum and resources to support students in engaging in artistic data literacy practices and projects. We worked with two 7th grade art teachers at two different schools, to implement and explore a lesson in which students engaged in creative expression with DataMeme to communicate about graphs of existing data. In this paper, we present findings from the implementation of the data lesson with 56 seventh graders, who examined data across different topics and created digital memes to communicate arguments about and with the data. Specifically, we examined two research questions:

- **RQ1.** In what kinds of data reasoning do students engage through their creation of data memes?
- **RQ2.** In what kinds of argumentation do students engage through their creation of data memes?

Through an analysis of 56 data memes and accompanying written explanations we present two key findings. First, through the process of constructing arguments, students engaged in complex forms of data reasoning. These acts of meme making led to instances of informal inferential reasoning [39, 40]. Second, by using meme structures learners engaged in particular approaches that made use of the data in different ways, and styles that varied in the communication of values, cultural references, and personal experiences. We demonstrate how these two competencies supported one another within their data meme argumentation.

The paper contributes to the literature by providing a set of illustrative examples that demonstrate the potential for data memes to broaden the ways learners can engage in data reasoning through narratives that force them to make intertextual and value-centric arguments around the data. We argue that DataMeme as an authoring tool can expand the potential for data memes by providing greater opportunities to move towards a more humanistic and interdisciplinary view of data literacy. Furthermore, we situate tools

such as DataMeme tool as an interdisciplinary resource that can potentially help teachers identify biases and inferences being made to create supportive dialogue.

2 BACKGROUND

2.1 Data Literacy

Data literacy can be understood as “the ability to ask and answer real-world questions from large and small data sets through an inquiry process, with consideration of ethical use of data” [62]. However, as an inquiry-focused process data literacy intersects and draws on multiple other literacies, including statistical literacy, scientific literacy, information literacy, media literacy, and critical literacy [3, 62]. Yet many existing efforts to promote data literacy are narrowly grounded in mathematics, focusing on important but insufficient concepts related to measures of center and standard deviation [17, 39]. Typical approaches to promoting data literacy focus narrowly on mathematics and statistics concepts with little relation to students' own experiences [17]. They tend to emphasize calculating measures of central tendency and reading and representing canonical visual representations with little context [39]. Such approaches often fail to engage students in reasoning meaningfully about data and what they represent.

Frameworks for informal statistical reasoning respond to criticism to schools' prioritization of detailed procedures, such as computing averages and reading graphs, over conceptual understandings of data [20, 53]. They propose three critical processes related to conceptions of informal statistical inference: the ability to use data as evidence, to employ probabilistic language, and to generalize beyond the data [39]. They further suggest that the ability to describe patterns in data is central [33, 40]. Engaging with data can lead to multiple other learning outcomes, including a better understanding of what data are and how to use them [27], and an ability to put mathematical and statistical knowledge into practice [41]. These objectives address persistent challenges that students have in working with data. For example, determining what counts as appropriate and sufficient evidence is challenging for students. They may rely solely on personal beliefs or fail to align data with their claims [29]. In data analysis, students often rely on case value comparisons, which limits their ability to make claims that go beyond the data [31, 32, 45]. In contrast, approaching data as an aggregate reinforces the value of calculating statistics [2, 32]. Finally, recognizing and communicating uncertainty within statistical claims engages students with tough topics such as the variability of data and challenges misconceptions that data are neutral and objective. To demonstrate informal inference-making, students might generate hypotheses, evaluate claims, or make predictions based on statistics [39]. In particular, a focus on argumentation through informal inference making significantly overlaps with information literacy, in that students are constructing a form of informational text [14], which requires accessing and using information effectively, as well as understanding the social issues surrounding the use of information [5].

2.2 Leveraging Personal Knowledge and Contexts

A handful of recent educational initiatives have begun to incorporate different disciplinary perspectives and foci to increasing the relevance of data literacy to local and personal issues. For example, those in K-12 contexts have engaged a variety of situated data literacy contexts that include mapping local lottery participation for math learning [49], using open data to understand one's community [24], having youth use journalistic science infographics to report on community issues [23], and tracking physical activity during recess to promote statistical reasoning and self reflection [36]. Additionally, educators have tackled broader social issues by exploring open community data to promote science learning [61], building mathematics and statistics literacies through examination of social justice issues [38], connecting data science to AI [34], and guiding students' in programming data-driven sketches to visualize patterns in the physical sciences [25]. Such efforts echo recent expansion of STEM curricula that explicitly taps into students' funds of knowledge, which is a particular focus for bridging the gap between home and school life for culturally-diverse students where there is a disconnect between what they know and how they learn at home versus at school [46, 54]. For instance in work by Mills et al. [42], children were found to bring their own language, practices, and forms of knowing when engaging in science learning, in ways that illuminate their scientific thinking.

One such approach that allows for surfacing intuitive, and possibly unconventional funds of knowledge, that can contribute to data reasoning is the use of strategies that incorporate iterative reflection on the context from which data are derived [7] and building on students' intuitive ways of "seeing" data through careful selection of data and representations [32, 33]. Engaging with multiple representations, including canonical and student-generated representations, can help students to develop scientific argumentation [8], and enhance their representational competence [12, 23]. These approaches align with perspectives that frame data visualization as visual argument and persuasion that shares much with rhetoric and writing [63].

2.3 Memes as Argumentation Artifacts

Memes have become familiar and visible artifacts of contemporary digital culture and many can be understood as forms of visual argumentation [30]. Visual rhetoric understands visual texts as created to construct meaning [16]. In particular, memes often derive their rhetorical power through engaging the viewer in the completion of visual enthymemes - an argument in which one premise is not explicitly stated [4]. In this way, both the construction and understanding of memes relies on collective knowledge [37] that includes the diverse language, practices, and forms of knowing we described earlier as students' funds of knowledge.

In addition to the use of visual enthymemes, memes also derive their rhetorical power from intertextuality that commonly entails the juxtaposition of text and image, or of multiple different images, and the associations among them that forms the meme's argument [15, 58]. The embedded references and connections that a meme facilitates, adds to their generative potential and their ability to

articulate values through complex narrative approaches such as metaphor, cultural references, symbolism, and satire [50, 51].

Meme construction as an activity has been used to promote critical thinking with political topics [57]; connecting scientific literacy with students' sense of purpose [44]; and understanding interpersonal communication [43]. Oftentimes, memes use humor or irony in their approach to an event or topic [35, 50], creating an approachable format through which readers and creators can engage critique and critical thinking. For example, prior research has connected the use of ironic humor in digital communication to ways of addressing issues of marginalization [21]. While a robust body of work has examined the composition and messaging strategies that characterize memes as discursive texts [30, 51, 52], little research has explored the pedagogical value of meme creation in supporting data literacy skills. In this study we examine how students' process of constructing data memes can support their data reasoning and data argumentation, while showing how learners tap into their own funds of knowledge to interpret, understand, and contextualize data. While we use the term "data meme", we acknowledge that the creations are not assumed to be viral artifacts, but based on viral artifacts. Furthermore, we note that participants are relating their memes to existing data, rather than remixing the data. Despite these caveats we feel the term data meme captures the use of meme argumentation approaches based on data.

3 METHODS

3.1 Context and Participants

Fifty-six middle school students and two teachers across two schools participated in the study. All participants were proficient in English, and the study was conducted in English. In one school, the student population was: 33% White, 32% Black, 16% Hispanic, and 16% Asian. 46% of the student population qualifies for free or reduced lunch, 18% of students have disabilities, and 4% are English Language Learners. The other school was a private Catholic middle school located in a large urban area with a predominantly Latinx and Black or African American population (85%). The average median income household income in this area is \$34,000.

3.2 Tool

The DataMeme tool is a web-based application designed as part of a larger cross-curricular co-design project called Data Literacy Through the Arts (DLTA). The tool was tested for usability and input from teachers, and allows for the construction of brief imagery and text pairings that comment on one or more data graphs. The goal of the tool is to use narrative construction to engage in meaning-making about data. Within the tool, users create data memes by selecting imagery and writing text. As illustrated in Figure 1, the first step is to select a graph that will be the target of your data meme's argumentation. As listed in Table 1, graphs were sourced from three different sources, and students were prompted to choose a graph from any of the sources provided.

Once a graph is selected users can begin to construct their data meme. Users can search the Giphy library for imagery as illustrated in Figure 2a. As illustrated in Figure 2b, users can overlay text atop the imagery and include text that highlights the data the meme is



Figure 1: Screenshot of the sDataMeme tool. Step 1: Choosing a graph

Table 1: Data charts available

Data	Description
Youth and Technology (2018)	Graphs from Pew Research survey of teens and technology across the U.S. in 2018.
Perceptions on Police (2016)	Graphs from mappingpoliceviolence.org 2017 data on police violence.
Teens and Mental Health (2019)	Graphs from Pew Research survey of teens and mental health across the U.S. in 2019.

focused on. In the last step, users can generate a custom link to share.

3.3 Lesson Description

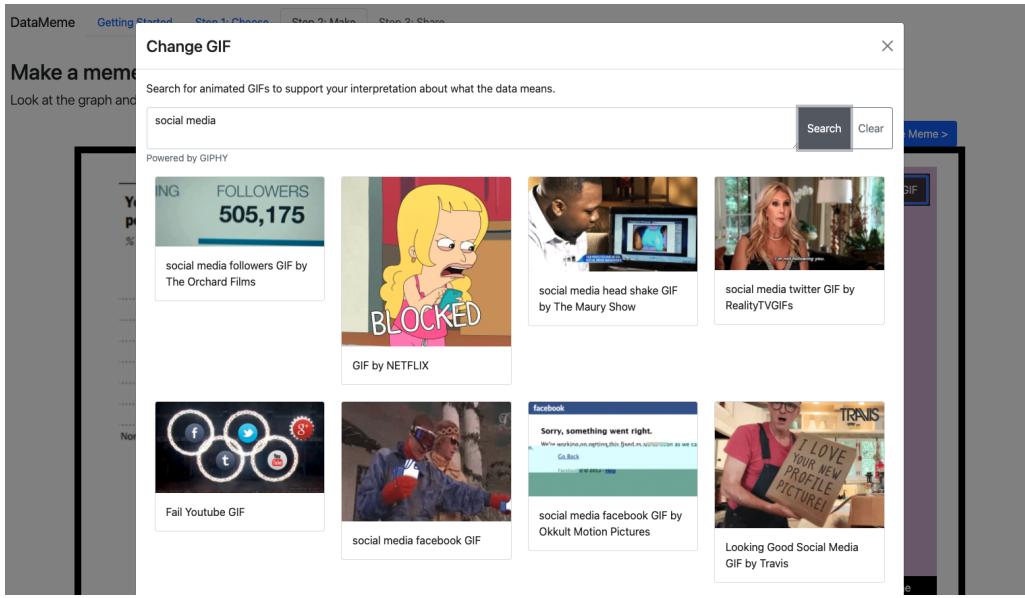
The 46-minute lesson began with a brief discussion of memes and how they are used in the everyday lives of students. The DataMeme tool was then introduced and the data memes on the initial page were discussed, focusing on the question, "what is being argued here?" The students were then tasked with using the tool to create two different data memes using the charts available in the tool and share the one they liked the most. In sharing their data meme students were prompted to provide a link to their meme as well as a written explanation that addresses the following questions: (i) what is your argument about the data, (ii) how does the data support your argument, (iii) why did you use the imagery you used, and (iv) what questions do you have about the data?

Prior to the lesson, students in both schools had previously engaged in learning to read bar graphs and pie charts across various data sets, which helped students in being able to effectively read and use the PEW data charts provided in the tool. While other data sets are loaded into the DataMeme tool, the PEW Research

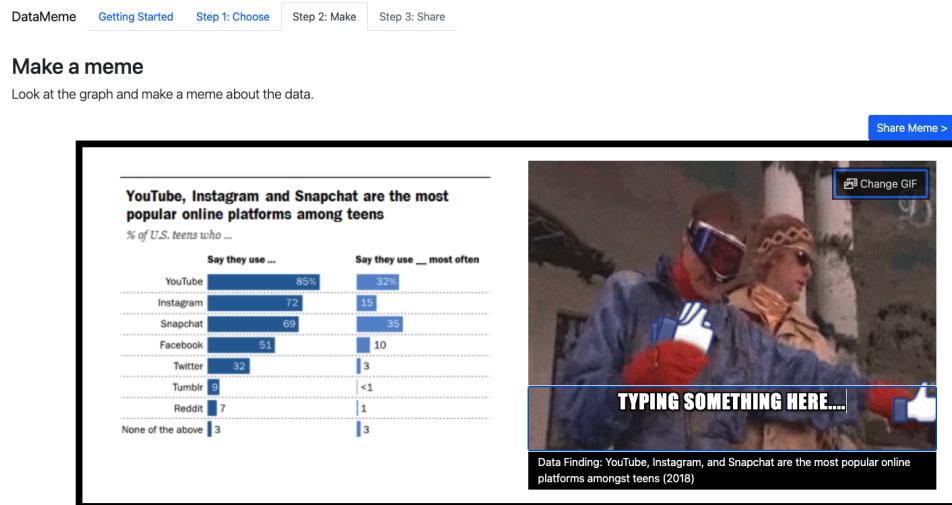
data was selected for this lesson given its focus on technology and prior interest in this topic by students. The lesson was conducted primarily in-person, with only five (11.2%) of the memes coming from a lesson conducted remotely.

3.4 Data and Analysis

The 56 data memes created by the students were coded by two researchers through an iterative, inductive coding analysis. The analysis of the data memes included the memes themselves (i.e. GIF they used, text they overlaid, and the graph they used), and any accompanying written explanations from the student that sought to explain their arguments and reasoning process. Two researchers individually explored 17% of the data (i.e. 10 memes) writing down what their initial perspectives were of how the students were creating an argument around the data, how their meme tried to communicate about their argument, and how their meme integrated the data. The researchers then got together and collaboratively discussed their findings to create an initial codebook consisting of codes related to the types of data reasoning the students engaged in, codes related to the students' use of imagery and text, and codes related to the rhetorical strategies and argumentation



(a) Step 2: Choosing imagery



(b) Step 2: Adding text

Figure 2: Screenshot of the DataMeme tool to add imagery and text

types integrated into the meme. The researchers went through two more rounds of iteratively re-coding and refining the codebook in order to reach consistency in how they were interpreting and applying the codes. At the end of the final round in which the researchers applied the codes to all 56 memes, there was only a discrepancy with the way 5% of the codes were applied. At this point the researchers then reviewed the discrepancies using a social moderation approach [18] where two researchers discussed their codes to come to a consensus. The final two groups of codes were around *Data Reasoning* (see Table 2) and *Argumentation* (see Table 3). The three data reasoning codes—*contextualizing the data*, *instance of the data*, and *implications of the data*—helped us identify what kinds of

data reasoning students engaged in as they integrated their ideas, perspectives, and reflections within the data memes. The five argumentation codes—*stereotype*, *conveys emotion*, *metaphor*, *conveys a value*, and *exaggeration*—provided insights into what kinds of argumentation students engaged in through their creation of data memes. The codes for argumentation tried to take in the sub-text of the meme and the surrounding images and text used.

Table 2: Data Reasoning Codebook

Code	Description
Contextualizing the Data	Interpretation of the data relationships in relation to context. Generalizing to context.
Instance of the Data	Meme serves as an illustrative example of the data or claim about the data referenced.
Implications of the Data	Reason about how data or other evidence support a hypothesis or claim.

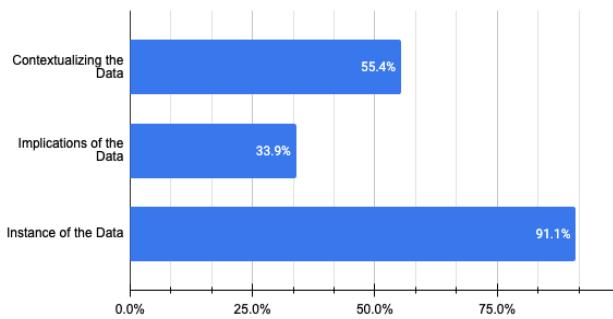
Table 3: Argumentation Codebook

Code	Description
Stereotype	Connecting to an existing exaggerated and oversimplified claim about a person or group
Conveys Emotion	Explicitly communicates an emotion or mood
Metaphor	Argument about one domain is situated in an related concept of another
Conveys a Value	Communicates a personal value through the meme
Exaggeration	Makes use of an exaggerated imagery or text that is not a metaphor

4 RESULTS

4.1 Data Reasoning

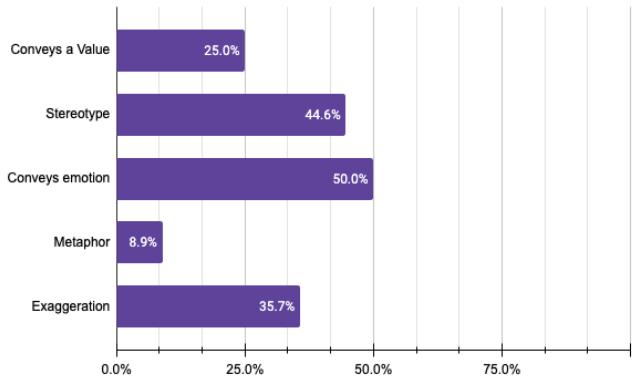
Our analyses demonstrate that students engaged in three types of data reasoning within their data memes (Figure 3) that aligned with forms of inference making (e.g, generalize beyond the data). The most prevalent form of data reasoning was *instance of the data*, which involved providing an illustrative example of the data or claim about the data referenced (91.1% | 51 data memes). The next two types of data reasoning tagged within the data memes were *implication assumption* (33.9% | 19 data memes), which sought to identify the impacts of the data being the way it is, and *contextualizing the data* that sought to explain why the data is the way it is either by providing context or making a causal connection (55.4% | 31 data memes). We will examine how these codes manifested within the Findings section.

**Figure 3: Data reasoning code frequencies**

4.2 Argumentation

Our analyses of the argumentation approaches taken in the data memes demonstrated the ways in which students used their own

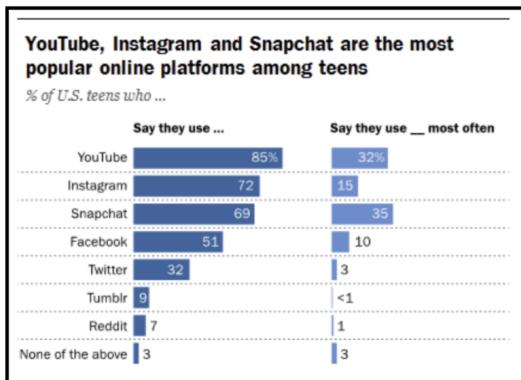
experiences and knowledge to both make sense of the data, and construct arguments that connect to an audience. As indicated in Figure 4, half of all data memes *conveyed emotions* in their argumentation (50% | 28 data memes). Less than half integrated a known *stereotype* (44.6% | 25 data memes). In addition, around one-quarter of the data memes *conveyed a value* (25% | 14 data memes). While students made use of exaggeration (35.7% | 20 data memes), students were less likely to use *metaphors* within their memes (8.9% | 5 data memes).

**Figure 4: Argumentation code frequencies**

An analysis was also conducted to explore the connection between co-occurring data reasoning and argumentation codes. About half of the memes coded as *contextualizing data* (51.61%) and half of memes coded as being an *instance of the data* (47.05%) were coded as *conveying an emotion*. Additionally, about half of the *contextualizing data* memes were also coded as including reference to a *stereotype* (51.61%). The other notable co-occurrences were *Contextualizing data* paired with *conveys a value* (25.49%), *instance of data* with



(a) Dog sitting in a room with flames saying 'This is Fine.' with text 'ME AFTER 10 HOURS OF YOUTUBE'



(b) Graph from PEW research Teens and Technology (2018)

Figure 5: DataMeme (D29)

conveys a value (25.49%), and implications of data where students also used a stereotype (36.84%).

5 FINDINGS

Our findings are organized based on the types of data reasoning we found within students' data memes (RQ1). Through examples, we highlight how particular types of data reasoning and associated argumentation approaches were apparent within the data memes (RQ2).

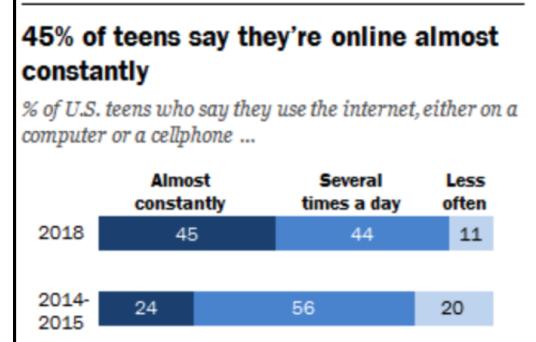
5.1 Instance of the Data

The most common type of data reasoning involved students describing an "instance of the data" or an instance of a claim based on the broader pattern shown in the data (91.1%). There were several notable ways in which students focused on particular instances in the data. One way was through situating themselves in the data based on their personal experiences. For example, when one student made a meme about how YouTube was one of the most popular social media platforms in 2018 they reflected on how they are, "on YouTube a lot" (5).

The author of the meme drew on a comical metaphor of the dog sitting nonchalantly in a house that is burning down. The metaphor relates to neglecting everything around them while being on YouTube.



(a) A person in bed that looks at her phone and makes a face with text that reads 'WHEN YOU WAKE UP TO MISSED GROUP CHAT MESSAGE'



(b) Graph from PEW research Teens and Technology (2018)

Figure 6: DataMeme (D27)

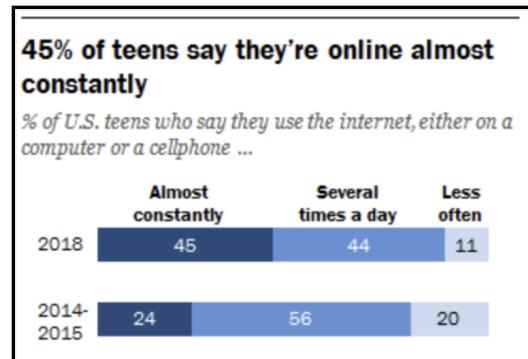
Students also described their individual experience in the context of their relationships to others. For instance in one data meme (see Figure 6), a student depicts an experience of waking up to missed group chat messages, based on the data that '45% of teens say they're online almost constantly.' The student described their data meme as referencing *that moment*, "when you wake up to loads of juicy group chat messages and you feel like you missed out but now you are back in."

In addition to connecting to their own habits and relationships within their lives, they also used the meme to convey their perspectives of others. Sometimes it was a value neutral instance in which they created a meme to visualize the data point (see Figure 7 using a dog typing to show how teens are online almost constantly—"The image I used showed a dog on his computer, not doing anything but looking at the screens which can connect to most kids as Covid forced them to stay home and usually avoid interacting with people at close distances").

Other times they used an instance in the data and made a value judgement about it within their meme. In Figure 6, for instance, a student is depicting how, "it can be very unhealthy how many times teenagers use social media but it makes them happy." This is also a good example of how students often chose imagery included characters that depicted pronounced and sometimes exaggerated



(a) A dog laying on a sofa with a blanket and typing on a computer rapidly with text that reads 'MOST OF THOSE KIDS BE LIKE.'

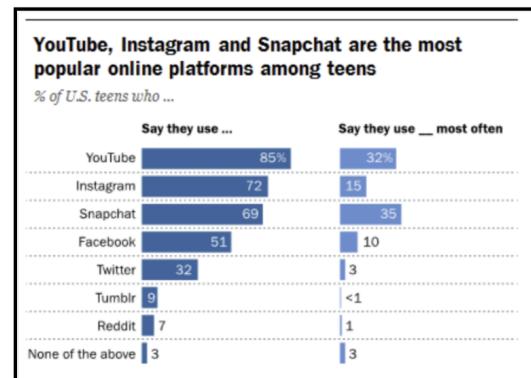


(b) Graph from PEW research Teens and Technology (2018)

Figure 7: DataMeme (D06)



(a) The Grinch looking evil with text that reads 'ME OPENING YOUTUBE FOR THE 12TH TIME TODAY'



(b) Graph from PEW research Teens and Technology (2018)

Figure 8: DataMeme (D07)

emotions that aligned with the argument or statement within their meme.

Some of the other explicit value judgements that students integrated in explanations about their memes included: "I want people to understand that they shouldn't not be friends with [someone] because of their race, gender, or ethnicity" (D05), "Don't judge people online for the way they do things" (D22), and "Peer pressure isn't worth it, so don't give into it. Don't feel pressured to do it" (D20).

There were only 5 memes that did not fit into this category of being an instance of the data. The ones in this *non-category* were either a reaction to the data itself (3 memes) or they were memes in which it was unclear how the imagery and text were related to the data (2 memes). D52 (Figure 9), was one of the reactionary memes. It integrates their relationship with their mom, in order to communicate about the generational differences in social media platforms that is not depicted in the data.

5.2 Contextualizing the Data

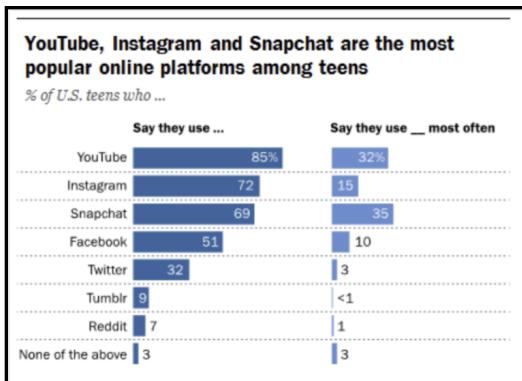
In 55.4% of data memes students engaged in contextualizing the data, or in other words, interpretation of the data relationships in relation to context.

One way in which students contextualized the data was through consideration of related causes that might explain why the data are how they are. For example in one data meme, the student considers the underlying causes that might result in parents sharing how much time they spend with their children. As illustrated in Figure 10, the student argues that students not wanting to spend time with their parents might relate to how much time parents say they spend with their kids. In many instances, this contextualization was tied to personal values - 32.26% of memes coded as contextualizing were also coded as conveying a value. In this instance, the student shared that their argument is about, "the disrespect kids have for their parents because many just use their parents for food, money, electronics and more." They expand their reasoning, sharing, 'kids



YouTube, Instagram, and Snapchat are the most popular online platforms amongst teens (2018)

(a) Britney Spears with a questioning/disbelieving look on her face with text that says, 'WHEN MY MOM ASKS WHERE MYSPACE IS ON THE LIST'



(b) Graph from PEW research Teens and Technology (2018)

Figure 9: DataMeme (D52)

don't wanna hang out with their parents when they don't see that life is to short so you wanna spend time with their parents.'

Another way students contextualized the data was through the association of relevant phenomena outside of a causal relationship. For example, in one data meme (see Figure 11), the student describes the context of feeling a certain kind of pressure, peer pressure. The student represents peer pressure through the imagery of someone asking you to sit close to them in a dark room. The conveying of a value is once again paired with this contextualizing as the student overlays text in their data meme that reads, 'PEOPLE TRYING TO PEER PRESSURE MEME, BUT NOT GIVING IN BECAUSE IT WONT BE WORTH IT.' The student further elaborates in their written explanation that their argument is, 'peer pressure isn't worth it, so don't give into it. Don't feel pressured to do it'



#SCHEETS CREEK 45% of parents say they spend too little time with their teenage children (2019)

(a) A woman shaking her head (no) dramatically with data text '45% of parents say they spend too little time with their teenage children (2019)'

% of parents who say they spend ___ time with their teenage children



% of teens who say they spend ___ time with their parents



Among teens - Household income



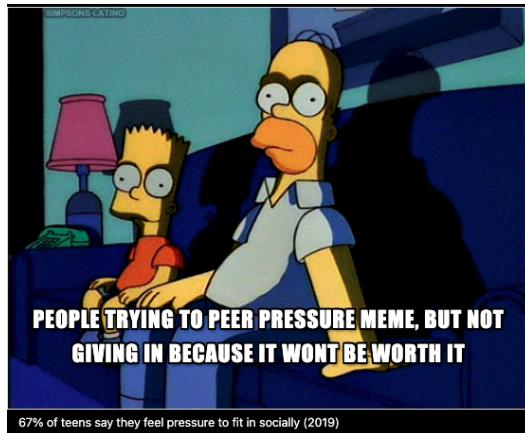
(b) Graph from PEW Research Teens and Mental Health (2019)

Figure 10: DataMeme (D3)

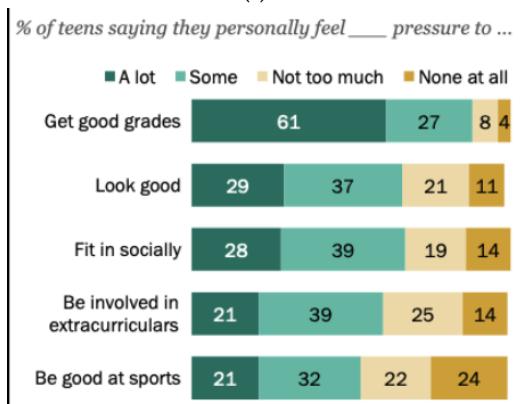
5.3 Implications of the Data

Another kind of data reasoning students engaged in was the consideration of the implications of the data. 33.9% of the data memes were coded as engaging in reasoning around the **implications of the data**, where the data meme depicts reasoning around what might occur as a result of the data.

For example, one student constructed a data meme (see Figure 12) that connected data on video game use to issues in the transfer of capital underlying the gaming marketplace. The student describes their argument as:



(a)



(b) Graph from

Figure 11: DataMeme (D20)

"I want people to take away the fact that teens play so much video games and purchase a bunch of virtual items in games they are helping game creators be rich and are spending most of their money on virtual game cosmetics losing the money to game creators."

While we did not see a high degree of visual metaphors (only 8.9% used metaphors) this meme does provide an example of the kind of creative use of imagery students used (e.g., showering in money).

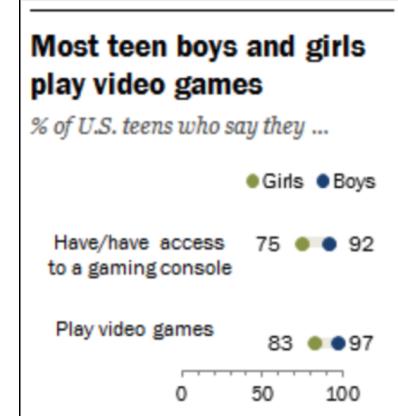
The ways in which stereotypes of groups or peoples became connected to reasoning around the implications of data was evident in 36.84% of data memes that were coded as implications of data. For example, in one data meme (see Figure 13) the stereotypes around teens procrastinating due to technology was communicated through humor and metaphor depicting an animal (representing things that need to be done) getting thrown from a cliff (representing procrastination).

6 DISCUSSION

This study explores the role that data memes can play in supporting data reasoning through argumentation, surfacing students' funds



(a) A cartoon character being showered with gold coins with text reading "SUCCESSFUL VIDEO GAME CREATORS"



(b) Graph from PEW research on Teens and Technology (2018)

Figure 12: DataMeme (D55) with text at bottom "Most teen boys and girls play video games (2018)"

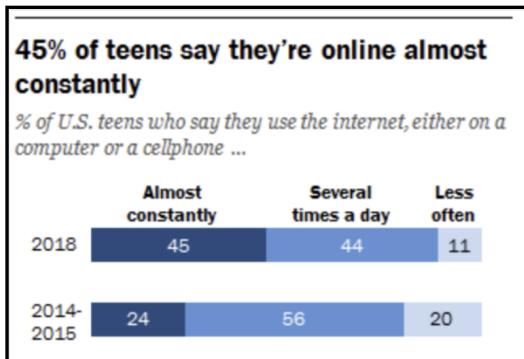
of knowledge and biases. Our results demonstrate that students created arguments that reflected different kinds of data reasoning such as considering contexts, implications, and relevant experiences. Moreover, data meme construction leveraged the rhetorical affordances of memes to support the conveying of emotions and values alongside cultural stereotypes and personal biases.

6.1 Making Memes and Data Reasoning

Through the construction of data memes, students moved from aggregated data points to narratives that sought to express a point of view or argument. In line with efforts to move data literacy towards a more humanistic stance, the kinds of data reasoning students engaged in through their creation of data memes, are the kinds that "humanize the personal narratives behind the numbers" [1]. Through surfacing instances of the data, considering contexts in which data lives, and reflecting on the implications that data may



(a) Rafiki tosses Simba over the cliff in contradiction to the movie.



(b) Graph of '% of U.S. teens who say they use the internet, either on a computer or a cellphone'.

Figure 13: DataMeme (D1) with text at the bottom “45% of teens say they’re online almost constantly (2018)”

have, students engaged in a form of data reasoning that connects data to their lives, relationships, and beliefs.

While the process of constructing data meme narratives that supported different kinds of data reasoning, the associations on the data activated students' funds of knowledge such as their own experiences, assumptions, and value systems. For instance, we saw evidence of students reasoning around how the data may be implicated in the future. Similar to what Curcio [6] called reading beyond the data, here students made inferences from the data (e.g., excessive time online may impact academic behavior) by tapping their existing schema for information (e.g., online platforms can become addictive and habitual) that is not explicitly stated in the data. The construction of data memes enabled learners to explore their own narratives and funds of knowledge that the data represent and hypothesize about other narratives implicit in the data. Using informal inference, students used the memes as forms of theorizing to account for the data in relation to the context.

In reasoning about experiences that might be situated in the data, many students tapped into their own experiences, assessing the ways in which these experiences fit into both the data contexts, and the broader rhetorical goals of their meme. For instance, students thought about how data on time teens spend online are connected to feelings of fear of missing out. In reasoning about the context in

which data lives, students considered related data that might not be in the dataset, yet present interesting connections. For instance, students thought about how attitudes about spending time with parents might influence how much time parents report spending with their teenage children. In reasoning about the implications of the data, students considered what implications data might have. For instance, students thought about how the prevalence of mental health issues amongst teens may lead to greater issues with seeing one's mental illness as their identity.

This reasoning, through the meme affordances of intertextuality and visual argumentation, reveal students' assumptions and value systems in ways that connect to their funds of knowledge and perspectives on why we might care about certain data. In some cases, the data memes were able to integrate assumptions and biases about the data and data points that are not supported. The meme form provides the opportunity to elaborate on what is not there. However, we see this as a potential jumping off point to use the data meme artifacts as not the final conclusions drawn from the data, but as a tool within the sense-making process. In line with research by Hancock et al. [26], there are a variety of challenges in connecting students' statistical questions to the data needed as evidence, and then again linking their conclusions back to the questions under investigation. In future work, there is promise for them to augment the discussions surrounding claims within their data arguments, and additional contextual questions that the data has not yet answered—i.e. a process that Wild and Pfannkuch [60] referred to as *shuttling* between the *statistical sphere* and the *context sphere*.

6.2 Potential Connections to Critical Literacies

The emerging connection between critical literacies and data literacy centers the non-neutral nature of data and communications about/with data [11]. Supporting the process of drawing connections between data and students' funds of knowledge calls for a negotiation of what can be said from the data, and what might be assumed in ways that reveal both our own biases, values, and broader cultural contexts that mediate our meaning-making with data. For instance, what is revealed in a data meme about children not wanting to spend time with their parents was also the student's values of equating time as a proxy for respect and gratitude to parents. In this way, this connection of data reasoning to funds of knowledge aligns with emerging data feminist principles of embracing pluralism, whereby "local and experiential ways of knowing" can be synthesized with data to provide multiple perspectives that contribute to more "complete knowledge" [11].

In other instances, students' arguments with the data memes revealed values that intersect with power, such as data memes that framed those that make friends with others that don't share one's own racial or gender background in a positive light, or that connected perceptions of encounters with the police with shifts in compliance behaviors. In this way, the connection of data reasoning to funds of knowledge aligns with emerging data feminist principle to "consider context" that centers the importance in "analyzing social power in relation to the data setting" [11].

The conveying of emotions that was evident in many of the data memes connecting contexts, implications, and experiences to

embodied experiences of affect. For instance, in considering the implications of data, some memes also conveyed the emotions such implications may trigger. In this way, the connection of data reasoning to funds of knowledge aligns with emerging data feminist principle to "elevate emotion and embodiment" which asks us to value knowledge that includes "living, feeling bodies in the world" [11]. Additional forms of argumentation such as the use of exaggeration are meant to elicit emotional reactions to data, creating new forms of engagement with rhetoric and perspectives on data.

This explicit surfacing of funds of knowledge as it relates to meaning-making with data creates opportunities for teachers to use a tools such as DataMeme to trigger discussions on the role of bias, power, and embodied experiences in inference- and sense-making.

7 CONCLUSION

The classroom environment can bring with it ideological boundaries around what kinds of knowledge is valuable, alongside practical boundaries such as how much time is available to generate personally meaningful data. Tools such as DataMeme present an approach to engage with data that already exists in ways that activate students' existing funds of knowledge through the enactment of data reasoning. A centering of data reasoning connected to argumentation through creative expression can be part of other approaches that seek to build one's capacity to read, manipulate, communicate, and produce data in ways that expose its non-neutrality. Echoing Tygel and Kirsch [55], who draws a parallel between data literacy and the critical pedagogy of Brazilian educator Freire [19], literacy goes beyond just reading words, but about reading the world. As a form of rhetorical construction [47], making memes can invite learners to bring their own knowledge, perspectives, and experiences to making meaning with data.

8 SELECTION AND PARTICIPATION OF CHILDREN

All procedures were approved by the Institutional Review Boards at the participating schools as well as the institutions of the researchers. Participants were recruited as part of a broader study co-designing data literacy curriculum with teachers. Data from students was entirely de-identified by teachers.

REFERENCES

- [1] Aria Almalhodaei, Alexandra P Alberda, and Anna Feigenbaum. 2020. 21. Humanizing data through 'data comics': An introduction to graphic medicine and graphic social science. In *Data Visualization in Society*. Amsterdam University Press, 347–366.
- [2] Arthur Bakker and Koen P E Gravemeijer. 2004. Learning to Reason about Distribution.
- [3] Rahul Bhargava, Erica Deahl, Emmanuel Letouzé, Amanda Noonan, David Sankokya, and Natalie Shoup. 2015. Beyond data literacy: Reinventing community engagement and empowerment in the age of data. (2015).
- [4] J Anthony Blair. 2012. The rhetoric of visual arguments. In *Groundwork in the Theory of Argumentation*. Springer, 261–279.
- [5] Katherine T Bucher. 2000. The importance of information literacy skills in the middle school curriculum. *The Clearing House* 73, 4 (2000), 217–220.
- [6] Frances R Curcio. 1989. *Developing Graph Comprehension. Elementary and Middle School Activities*. ERIC.
- [7] Robert C del Mas. 2004. A comparison of mathematical and statistical reasoning. In *The Challenge of Developing Statistical Literacy, Reasoning and Thinking*. Springer, 79–95.
- [8] Mehmet Demirbag and Murat Gunel. 2014. Integrating Argument-Based Science Inquiry with Modal Representations: Impact on Science Achievement, Argumentation, and Writing Skills. *Educational Sciences: Theory and Practice* 14, 1 (2014), 386–391.
- [9] Catherine D'Ignazio. 2017. Creative data literacy: Bridging the gap between the data-haves and data-have nots. *Information Design Journal* 23, 1 (2017), 6–18.
- [10] Catherine D'Ignazio and Rahul Bhargava. 2016. DataBasic: Design principles, tools and activities for data literacy learners. *The Journal of Community Informatics* 12, 3 (2016).
- [11] Catherine D'Ignazio and Lauren F Klein. 2020. *Data Feminism*. MIT press.
- [12] Andrea A Disessa. 2004. Metarepresentation: Native competence and targets for instruction. *Cognition and Instruction* 22, 3 (2004), 293–331.
- [13] DLTA. 2022. Data Literacy Through the Arts. <https://sites.google.com/nyu.edu/data-literacy-through-the-arts/>
- [14] Nell K Duke. 2009. Informational text and young children: When, why, what, where, and how. *National Geographic Learning: Best Practices in Science Education* (2009).
- [15] Janis L Edwards. 2004. Echoes of Camelot: How images construct cultural memory through rhetorical framing. *Defining Visual Rhetorics* (2004), 179–194.
- [16] Sonja K Foss. 2004. Framing the study of visual rhetoric: Toward a transformation of rhetorical theory. *Defining Visual Rhetorics* (2004), 303–313.
- [17] Christine Franklin, Gary Kader, Denise Mewborn, Jerry Moreno, Roxy Peck, Mike Perry, and Richard Scheaffer. 2007. Guidelines for Assessment and Instruction in Statistics Education (GAISE) report.
- [18] John R Frederiksen, Mike Sipus, Miriam Sherin, and Edward W Wolfe. 1998. Video portfolio assessment: Creating a framework for viewing the functions of teaching. *Educational Assessment* 5, 4 (1998), 225–297.
- [19] Paulo Freire. 2018. *Pedagogy of the Oppressed*. Bloomsbury publishing USA.
- [20] Susan N Friel, Frances R Curcio, and George W Bright. 2001. Making sense of graphs: Critical factors influencing comprehension and instructional implications. *Journal for Research in Mathematics Education* 32, 2 (2001), 124–158.
- [21] Noam Gal. 2019. Ironic humor on social media as participatory boundary work. *New Media & Society* 21, 3 (2019), 729–749.
- [22] Joan B Garfield, Dani Ben-Zvi, Beth Chance, Elsa Medina, Cary Roseth, and Andrew Zieffler. 2008. *Developing students' statistical reasoning: Connecting research and teaching practice*. Number Sirsi) 19781402083822. Springer.
- [23] Engida H Gebre and Joseph L Polman. 2016. Developing young adults' representational competence through infographic-based science news reporting. *International Journal of Science Education* 38, 18 (2016), 2667–2687.
- [24] Robert Gould, Suyen Machado, Christine Ong, Terri Johnson, James Molyneux, Steve Nolen, Hongsuda Tangmunarunkit, L Trusela, and Linda Zanontian. 2016. Teaching data science to secondary students: The mobilize introduction to data science curriculum. *Iase-Web.Org* (2016).
- [25] Brian E Gravel and Michelle H Wilkerson. 2017. Integrating computational artifacts into the multi-representational toolkit of physics education. In *Multiple Representations in Physics Education*. Springer, 47–70.
- [26] Chris Hancock, James J Kaput, and Lynn T Goldsmith. 1992. Authentic inquiry with data: Critical barriers to classroom implementation. *Educational Psychologist* 27, 3 (1992), 337–364.
- [27] Scott Heggen, Osarieme Omokaro, and Jamie Payton. 2012. Mad Science: Increasing engagement in STEM education through participatory sensing. In *Proc. of the Sixth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies*. Citeseer.
- [28] Peter Holmes. 2003. 50 years of statistics teaching in English schools: Some milestones. *Journal of the Royal Statistical Society: Series D (The Statistician)* 52, 4 (2003), 439–463.
- [29] Barbara Hug and Katherine L McNeill. 2008. Use of first-hand and second-hand data in science: Does data type influence classroom conversations? *International Journal of Science Education* 30 (10 2008), 1725–1751. Issue 13. <https://doi.org/10.1080/09500690701506945>
- [30] Heidi E Huntington. 2013. Subversive memes: Internet memes as a form of visual rhetoric. *AoIR Selected Papers of Internet Research* (2013).
- [31] Jennifer Kahn. 2020. Learning at the intersection of self and society: The family geobiography as a context for data science education. *Journal of the Learning Sciences* 29 (1 2020), 57–80. Issue 1. <https://doi.org/10.1080/10508406.2019.1693377>
- [32] Clifford Konold, Traci Higgins, Susan Jo Russell, and Khalimahtul Khalil. 2015. Data seen through different lenses. *Educational Studies in Mathematics* 88 (3 2015), 305–325. Issue 3. <https://doi.org/10.1007/s10649-013-9529-8>
- [33] Clifford Konold and Alexander Pollatsek. 2002. Data analysis as the search for signals in noisy processes. *Journal for Research in Mathematics Education* 33, 4 (2002), 259–289.
- [34] Shriram Krishnamurthi, Emmanuel Schanzer, Joe Gibbs Politz, Benjamin S Lerner, Kathi Fisler, and Sam Dooman. 2020. Data science as a route to ai for middle and high school students. *arXiv preprint arXiv:2005.01794* (2020).
- [35] Liisi Laineste and Piret Voolaid. 2016. Laughing across borders: Intertextuality of internet memes. *The European Journal of Humour Research* 4, 4 (2016), 26–49.
- [36] Victor R Lee, Joel R Drake, and Jeffrey L Thayne. 2016. Appropriating quantified self technologies to support elementary statistical teaching and learning. *IEEE*

Transactions on Learning Technologies 9, 4 (2016), 354–365.

[37] Ioana Literat and Sarah van den Berg. 2019. Buy memes low, sell memes high: Vernacular criticism and collective negotiations of value on Reddit's MemeEconomy. *Information, Communication & Society* 22, 2 (2019), 232–249.

[38] J Louie, J Stiles, E Fagan, S Roy, and B Chance. [n. d.]. Data investigations to further social justice inside and outside of STEM. *Connected Science Learning* 3, 1 ([n. d.]).

[39] Katie Makar and Andee Rubin. 2009. A framework for thinking about informal statistical inference. *Statistics Education Research Journal* 8, 1 (2009).

[40] Katie Makar and Andee Rubin. 2018. Learning about statistical inference. *International Handbook of Research in Statistics Education* (2018), 261–294.

[41] Jane Margolis, Joanna Goode, and David Bernier. 2011. The need for computer science. *Educational Leadership* 68, 5 (2011), 68–72.

[42] Kelly Mills, Elizabeth Bonsignore, Tamara Clegg, June Ahn, Jason Yip, Daniel Pauw, Lautaro Cabrera, Kenna Hernly, and Caroline Pitt. 2019. Connecting children's scientific funds of knowledge shared on social media to science concepts. *International Journal of Child-Computer Interaction* 21 (2019), 54–64.

[43] Aditi Paul. 2020. Memes as means for understanding interpersonal communication: A formative assignment. *Communication Teacher* 34, 4 (2020), 346–354.

[44] Diana K Riser, Stephanie D Clarke, and Allison N Stallworth. 2020. Scientific memes: Using the language of social media to improve scientific literacy and communication in lifespan development. *Psychology Learning & Teaching* 19, 3 (2020), 275–289.

[45] Jessica Roberts and Leilah Lyons. 2020. Examining spontaneous perspective taking and fluid self-to-data relationships in informal open-ended data exploration. *Journal of the Learning Sciences* 29, 1 (2020), 32–56.

[46] Gloria M Rodriguez. 2013. Power and agency in education: Exploring the pedagogical dimensions of funds of knowledge. *Review of Research in Education* 37, 1 (2013), 87–120.

[47] Jeremy Roschelle, Wendy Martin, June Ahn, and Patricia Schank. 2017. *Cyber-learning community report: The state of cyberlearning and the future of learning with technology*. Technical Report. SRI International.

[48] Andrew S Ross and Damian J Rivers. 2017. Internet memes as polyvocal political participation. In *The Presidency and Social Media*. Routledge, 285–308.

[49] Laurie H. Rubel, Vivian Y. Lim, Maren Hall-Wieckert, and Mathew Sullivan. 2016. Teaching mathematics for spatial justice: An investigation of the lottery. *Cognition and Instruction* 34 (1 2016), 1–26. Issue 1. <https://doi.org/10.1080/07357008.2015.1118691>

[50] Limor Shifman. 2014. The cultural logic of photo-based meme genres. *Journal of Visual Culture* 13, 3 (2014), 340–358.

[51] Limor Shifman. 2019. Internet memes and the twofold articulation of values. *Society and the Internet: How Networks of Information and Communication are Changing our Lives* (2019), 43–57.

[52] Blaine E Smith, Ji Shen, and Shiyang Jiang. 2019. The science of storytelling: Middle schoolers engaging with socioscientific issues through multimodal science fictions. *Voices from the Middle* 26, 4 (2019).

[53] M Alejandra Sorto. 2006. Identifying content knowledge for teaching statistics. In *Working Cooperatively in Statistics Education: Proceedings of the Seventh International Conference on Teaching Statistics, Salvador, Brazil*. [CDROM]. Voorburg, The Netherlands: International Statistical Institute. [Online: <http://www.stat.auckland.ac.nz/~iase/publications/17/C130.pdf>].

[54] Chris Street. 2005. Funds of knowledge at work in the writing classroom. *Multicultural Education* 13, 2 (2005), 22–25.

[55] Alan Freihof Tygel and Rosana Kirsch. 2016. Special Issue on Data Literacy: Articles Contributions of Paulo Freire to a Critical Data Literacy: a Popular Education Approach. *The Journal of Community Informatics* 12 (2016), 108–121. Issue 3. www.eita.org.br.

[56] Jacqueline Ryan Vickery. 2014. The curious case of confession bear: The reappropriation of online macro-image memes. *Information, Communication & Society* 17, 3 (2014), 301–325.

[57] Dominic D Wells. 2018. You all made dank memes: Using internet memes to promote critical thinking. *Journal of Political Science Education* 14, 2 (2018), 240–248.

[58] Bradley E Wiggins. 2019. *The Discursive Power of Memes in Digital Culture: Ideology, Semiotics, and Intertextuality*. Routledge.

[59] CJ Wild, Maxine Pfannkuch, Matthew Regan and Nicholas J Horton. 2011. Towards more accessible conceptions of statistical inference. *Journal of the Royal Statistical Society: Series A (Statistics in Society)* 174, 2 (2011), 247–295.

[60] Chris J Wild and Maxine Pfannkuch. 1999. Statistical thinking in empirical enquiry. *International Statistical Review* 67, 3 (1999), 223–248.

[61] Michelle Hoda Wilkerson and Vasiliki Laina. 2018. Middle school students' reasoning about data and context through storytelling with repurposed local data. *ZDM - Mathematics Education* 50 (12 2018), 1223–1235. Issue 7. <https://doi.org/10.1007/s11858-018-0974-9>

[62] Annika Wolff, Daniel Gooch, Jose J Cavero Montaner, Umar Rashid, and Gerd Kortuem. 2016. Creating an understanding of data literacy for a data-driven society. *The Journal of Community Informatics* 12, 3 (2016).

[63] Moshon Zer-Aviv. 2014. Disinformation visualization: How to lie with datavis. URL: <http://www.visualisingadvocacy.org/blog/disinformation-visualization-how-to-lie-with-datavis> (accessed 15 April 2016) (2014).