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Dancing with Data: Embodying the Numerical and Humanistic Sides of Data

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Abstract: Data literacy is important for supporting individuals to incorporate information from research studies into their own perspectives and decision-making processes. However, it can be challenging for students to read, understand, and relate to data. Students have to be able to traverse the representational forms that data takes on (i.e., numerical, graphical, etc.) and connect it to their understanding of a topic. We explore the implementation of a co-designed data-dance unit in which middle school students created their own embodied metaphors to represent and communicate about graphs through dance. In analyzing dance artifacts and post-study interviews with the learners and teachers, we demonstrate how the creation of embodied metaphors in dance led to new ways of exploring the data as learners reflected on different perspectives on topics across numerical values, contexts, and implications.

Introduction

Dance encompasses technical and creative problem-solving practices that center the body. Dance education supports non-verbal expression that packs and unpacks meaning through movement (Hanna, 2008; Koff, 2000). Dance is not just a practice meant for professionals, but a discipline that offers everyone a way of developing "self-expression and interpretation through motion" (Koff, 2000). The unique embodied practices of dance create opportunities to expand the ways that learners can explore and build understanding with and about data. We co-designed a unit that combines math and contemporary dance practices in which learners explored a set of graphs about chosen topics, and developed dances to represent and communicate about their data. We present findings from this experience answering the following research question: ***How did learners engage in embodied meaning-making around data in a contemporary dance and data unit?***

Background Literature

Data Literacy and Data Art

Data literacy has been critiqued for focusing mostly on technical skills with disregard for broader concepts like *citizenship* and *empowerment,* which can exacerbate educational and social inequities (D'Ignazio, 2017). A creative data literacy framing that incorporates art production with data practices can attend to these issues (D'Ignazio, 2017) and help students achieve the same rigor in learning as traditional curricula (Bhargava et al., 2016). In particular, creative data literacy can support students in developing their identities in relation to data (Stornaiuolo, 2019) and seeing themselves as able to "speak data" through creative practices (D'Ignazio, 2017). Bhargava & D'Ignazio (2017), for instance, show that creating data sculptures helped students overcome initial barriers while attending to their complex ideas. Data art has helped students explore the social-situativity of data through developing narratives, argumentation, and perspective taking (Viégas & Wattenberg, 2007). Data sculptures, for example, have helped students develop their contextual understanding of data, connecting data sets to the social setting where it lives (Sauvé et al., 2020) and facilitated students' data interpretation in relation to the social context through the sculptures' ability to embody data using metaphors (Zhao & Moere, 2008).

Embodiment of Mathematical Concepts

Our work takes a grounded cognitive approach (Barsalou, 2010) to explore ways to promote engagement with data. Specifically, we examine how a data-dance context provides opportunities for learners to create embodied metaphors to think about, represent, and communicate about data. Research suggests that the embodiment of mathematical concepts can benefit students' learning of abstract ideas in math (Moerman, 2016; Mickelson & Ju, 2010). Several studies have found a positive link between physical movement and cognitive skills associated with mathematical concepts (Fenyvesi et al., 2019; Namukasa et al., 2007). For instance, work by Rosenfeld (2013)

supported children in understanding mathematical concepts by building original choreographies. Similarly, Helsa and Hartono (2011) found that traditional dance could support students' understanding of symmetry. Embodied metaphors with dance have the potential to center the body, movement, improvisation and play within our reflective practices (Petsilas et al., 2019). Divergent approaches to data literacy education embrace context-bound inquiry and encourage the challenging of neutral, objective representations of data. In this study, we explore how dancing with and about data can support the understanding of mathematical concepts such as number sense, contextualization of data, and making meaning with data.

Methods

We engaged in co-design with one math and one dance teacher in a public charter school in the Midwestern United States. The teachers taught the data-dance unit to eleven 7th grade students who were in both the math and dance classes. The middle school student population is 65% White, 19% Hispanic, and 6% Black—46% of the student population qualifies for free or reduced lunch. A team of four researchers met every other week with the two teachers for a semester prior to implementation. They created activities to frame different concepts and determine how best to support students in creating a final dance performance integrating data. In the unit, students: (1) picked a topic of interest, (2) interpreted and analyzed data sources on that topic provided by the co-design team, and (3) created a dance in response to the data and their questions grounded in the data. Students performed these dances and presented an artist statement explaining them at an exhibition attended by other students, teachers, parents, and community members.

In the math classroom, students met over three weeks, for a total of six sessions. Topics of these lessons included statistical questions, data visualizations, measures of central tendency, and recognizing/interpreting trends in data. In the dance classroom, students met over 18 weeks (4 sessions per week), with the sessions starting prior to the math sessions. The teacher dedicated the first seven weeks of the semester to introducing contemporary dance and developing contemporary dance techniques with students. In Weeks 8 and 9, students created a smaller scale, collective version of the larger project (interpreting data, creating questions, and developing dances in response). In Weeks 11-18, students independently created, presented, and reflected on their dances developed through an analysis of their graphs. We collected data from five separate project groups that engaged with data on: (1) *Women's Rights*—Emily, Gabby, Amber, Cameron, (2) *Minecraft*—Cory, (3) *Animal Populations*—Irene, Debbie, (4) *Mental Health*—Margaret, and (5) *Social Media and Mental Health*—Will, Brooke, Ashley. Student names used in the analysis are pseudonyms.

Our data include: student group interviews, dance planning materials, and a paired teacher interview. The student group interviews were conducted with each of the five student teams. The dance planning materials were created by each of the student teams and made them connect *claims/supports* from the data to *movements* in their dance. The paired teacher interview was conducted after unit implementation with both the art and math teachers. We engaged in an iterative coding process beginning with open descriptive coding (Saldaña, 2015) that was refined through social moderation (Frederiksen, 1998). For each iteration, conflicts and differences in interpretation were discussed and codes were refined. The codebook was reviewed and checked for clarity with researchers outside of the project team, who discussed the coding of a subset of data.

Findings

In this paper, we focus on one of our analytic themes, ***embodied data characteristics***—*characteristics of the data that students used to create embodied metaphors*. We identified three data characteristics that students used to create embodied metaphors: graph shape & numerical value, data context, and data implications (Table 1).

Table 1
Embodied Data Characteristics Codebook

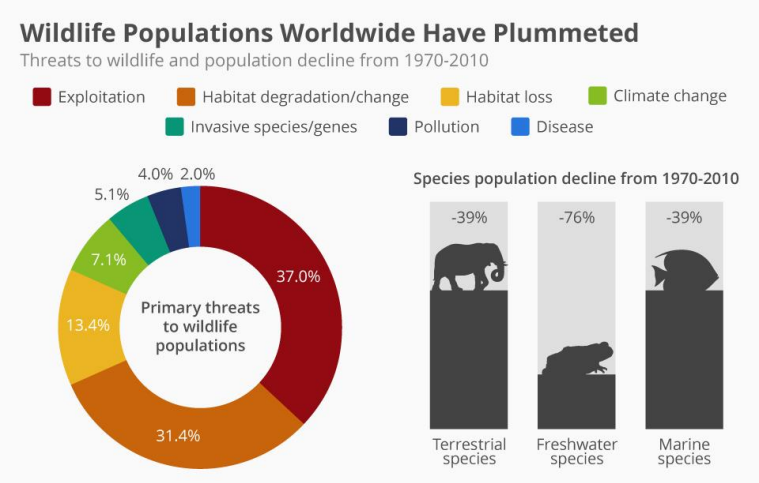
Graph Shape & Numerical Values	Movements representative of the physical appearance of the graph or the data patterns within the graphs (rate, percentage, or summary of data)
Context	Movements that provide an example of the data points, categories, or attributes.
Implications	Movements representative of what happens as a result of the data

Embodying Graph Shape & Numerical Value

One of the initial activities, students engaged in with their graphs was to explore the shape of a graph through movement, "Like for one day, we would like physically shape out the graphs, like actually show the ups and

downs of it." One student in the animal populations group (Figure 1), explained how this was a useful exercise, "looking at [the graph] at different angles and like even just making its actual shape…really helped us understand how it was going down or up and in what ways we can help fix this...It made us look at the graphs in a different way. Like at all angles to figure out what is the best view we can get of this graph to make movements to help others understand what is happening."

Figure 1
Graph used by the Animal Populations Group (Statista, 2014)



Through examination of the shape the students began thinking about why the graph was the way it was. While this was a starter activity, the final performances often also had some movements where learners were embodying the graph shape or numerical values within the graph. Students would often transpose a dance dynamic, such as levels or body position, onto the value of a data descriptor of a categorical variable that they would embody within the movement. Emily in the women's rights group, for example, describes how her group embodied the different countries (Figure 2) in order to communicate the percentage of women and men who agree that "A woman's most important role is to take care of her home and children" (data in Figure 3): "[They] all came from a sitting position and rise up…representing certain countries…to show like how high the percentage was on the graph…I went from a higher position downward, [to] a really low percentage…we're trying to take the image of the graph into our dancing." Illustrated in Figure 2 are three dancers from the women's rights group (representing the majority from the graph data) rising up from a sitting position, while another dancer (representing North America) goes from standing to sitting. This movement drew the student's attention to what the data values were as well as the differences across categories, as well as changes over time. For example, in the Minecraft dance the student did a dance move where his forearm traced the shape of the data over time, "It is meant to represent the main change in the number of hours watched of Minecraft on Twitch and shape of the graph" (Figure 4).

Embodying the Context of the Data

Most of the movements that students discussed and performed embedded data into a context. At the high level, learners created movements that were literal relationships to their topic, such as Cory doing the robot walk to represent Minecraft. However, the majority of these movements embodied some trait or feature of a categorical variable or data point outside of the numerical value represented in the graph. For example, in the case of Debbie and Irene who created dance sequences that were graceful like a bird or representative of a fish's swimming movements, learners had to examine some aspect of the category beyond what was represented in the graph to create their movement. For example, Debbie and Irene also depicted exploitation:

> **Claim/Support**: One of the first things we noticed on this graph was that exploitation is one of the biggest causes of all of this. Exploitation is in this case when humans take advantage of animals and almost use them, giving nothing in return...
> **Movements**: In our dance we do a trust fall [deliberately falling and trusting someone to catch them] with a very narrow and low drop. This is showing how humans are taking animals for granted

Figure 2

Women's Rights Group performing a routine captured in three frames over time

Figure 3

Graph used by the Women's Rights Group (Facebook, 2021)

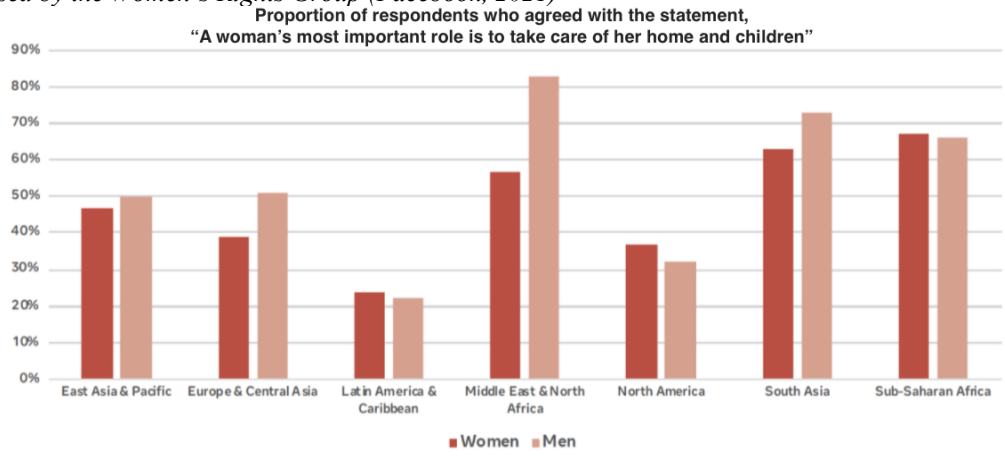
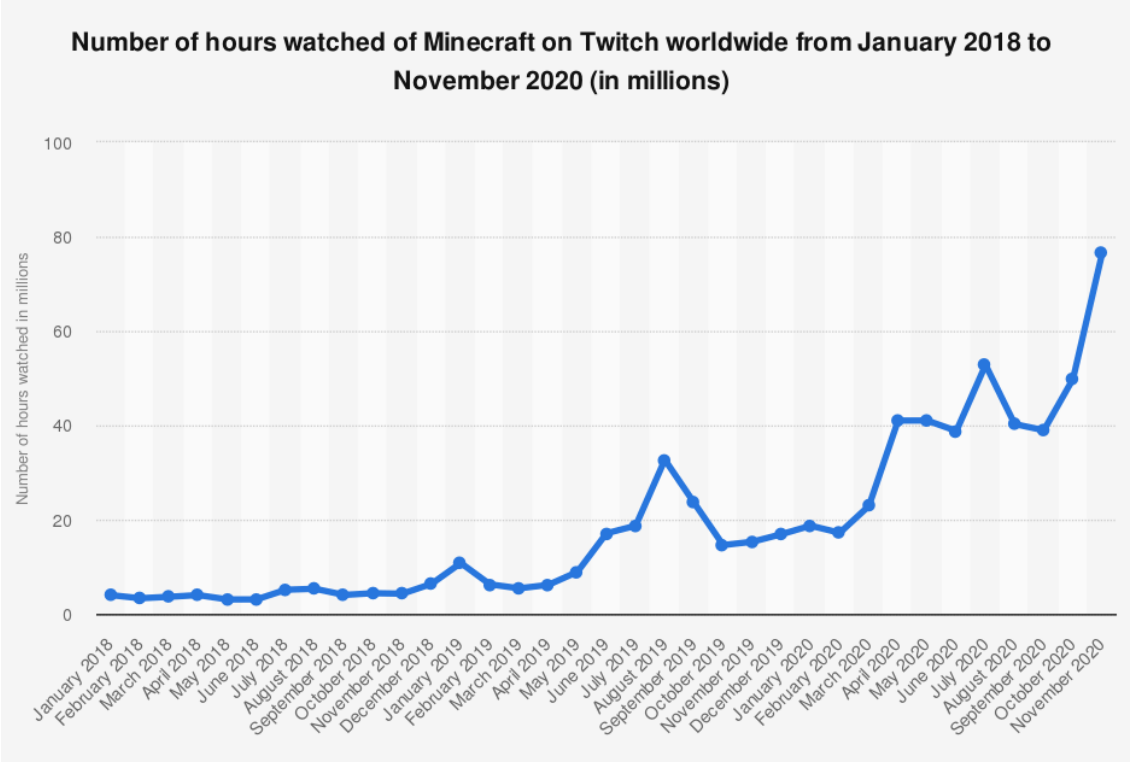


Figure 4

Graph used by Cory focusing on Minecraft (Statista, 2020)

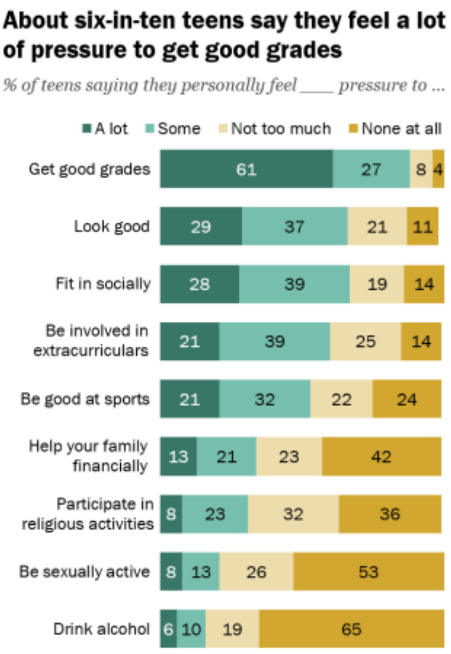


Similarly, Margaret highlighted how there was a higher percentage of girls receiving treatment for depression than boys. At one point in her dance, she "was looking more through the viewpoint of a girl. And doing those reaching movements helps me like show I was able to get help" (Figure 5b). Students also constructed narratives around the data illustrating how scenarios might play out around the data. For example, the Social Media and Mental Health group outlined a movement using the graph in Figure 5a:

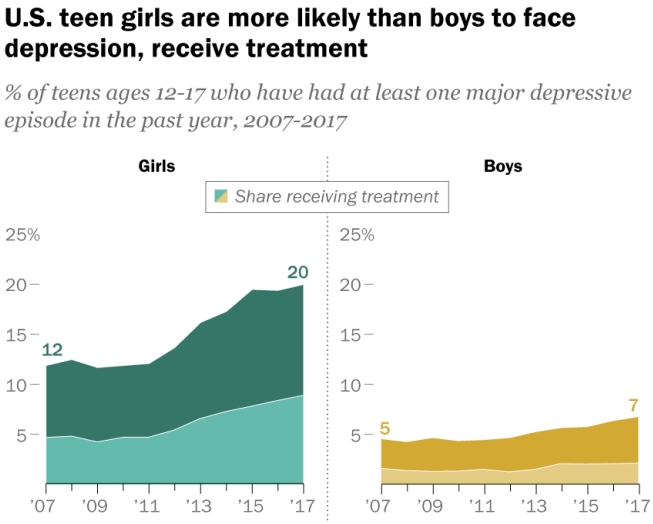
> **Claim/Support**: The main stressor that teens face is related to getting good grades in school. 88% of teens reported feeling at least some stress to get good grades.
> **Movements**: I fall down to represent struggling in school, then I pull back up the rope to represent getting back on track. I do this three times to show the ups and downs that teens face with getting [good grades].

Figure 5

(a) Graph used by the Mental Health and the Social Media and Mental Health group (Pew Research Center, 2018)



(b) Graph used by the Mental Health group (Pew Research Center, 2017)



Embodying Implications of the Data

In some of the movements, students began to explore the implications of the data through their choreography. In the Women's Rights group, their dance highlights what can happen if perceptions of a woman's role are changed,

> **Claim/Support**: While some regions have not changed their perception of what women can do, there are regions who have changed their perception. (The lower bars in North America/Latin America vs the higher bars in the middle east/asia) In those regions, women now take on different careers and have more freedom to work toward what they want to accomplish.
> **Movements**: All four dancers are representing females. We start by doing movements lower and work toward higher levels to show women working up toward their goals over time. All dancers then walk in circles to show different roles women can take if the perception is changed like it has been in…North America and Latin America.

Additionally, students created movements about what an attribute implied about a variable, such as Maragret in the mental health group showing the implications of lgbt youth who were not able to get mental health care,

Claim/Support: 16% of lgbt youth did not get mental health care because their parents did not allow them to go
Movements: "Shampoo" to express the feeling of being caged in, unable to move

Discussion: Evolving Data Practices with Dance

Dance practices fundamentally changed how learners built knowledge with data, including how they examined, reasoned around, related to, and represented the data. We focus on creation practices and performance practices.

Creation Practices: Data Reasoning through Embodied Metaphors

Learners needed to understand the data in order to translate it into a metaphor with bodily movements. The embodied metaphors covered the spectrum of what Zhao & Moore (2008) describe as the metaphorical distance from the data: these metaphors both drew attention to certain aspects of the data, while also *hiding* other aspects of the data. Part of learners' examination of their data involved embodied exploration of the numerical values and physical characteristics of the graph and the variables represented. They had to think through the values and angles within the graph then translate them into body positions and movements that they then experienced. This process helped students notice particular trends and compare values of categorical variables. This finding aligns with Goldin and Kaput's (2013) assertion that multimodal sensory imagery can help facilitate a *number sense,* which involves understanding the meaning and size of numbers as well as equivalent representations and expressions (McIntosh et al., 1992). In our work, learners were able to draw on the grounded kinesthetic and embodied modalities of dance to experience the data. This has implications for how the learners' number sense of the data is shifted by having to embody the data.

The learners also engaged in what Hanna (2008) calls "concretization" in which dancers reflect outward aspects of a concept through movement. Learners explored different aspects of the variables within the data and characteristics surrounding the data in the real world in order to create movements around it. This was evidenced by their exploration of how a fish moves, roles that women take on, or what exploitation means. *Concretizing* the data encouraged learners to think about and convey the broader context of the data, including the people, actors, environmental context, and emotions. At times they embodied the cases within the variables and other times they embodied things that were implicated within the cases in order to convey meaning. In Eisner's (1997) reflection on alternative forms of data representation in research, he highlights how examining different forms are necessary to cultivate data representations that stimulate empathy, connect to individuals in the data, and increase the types of questions that we ask about the data. As we try to humanize data for learners (Lee et al., 2021), examining artistic representational forms like dance show promise in the ways they facilitate a contextual grounding and reflection on people and the environment in ways that stimulate personal, cultural, and societal exploration.

The collaborative dances also stimulated learners to reason about data via each other's movement and body positions. The collaborative work expanded their potential region of focus on the data as they could now simultaneously represent multiple categorical variables or multiple actors in their metaphorical representations. This enabled them to portray relationships and interactions across the dancers and thus the data and actors they were representing. Through this process they reflected across the similarities and connections and the differences and departures in their representations. This was done in both the numerical sense—i.e. differences in value—and the characteristic sense—i.e. a woman's role versus a man's role. The representations conveyed a meaning that was dependent on the dancers coordinated movement together. The dance created opportunities for what Ma and Hall (2018) have termed *ensemble learning* wherein learners engage in collaborative activity that cannot be done alone and results in a performance. This type of learning stimulates engagement in the representations, learner agency over sections of a routine, and distributes mathematical concepts across learners. We observed ensemble learning as learners distributed roles within their danced metaphors to communicate through a "*sequence of unfolding movement,* including who does what to whom and how" (Hanna, 2008).

Performative Practices: Audience and Interpretation

The performances engaged the audience in cognitive sensemaking with data and in kinesthetic empathy—feeling as though their bodies are participating in the movements they see as well as experiencing the feelings that the performance evokes (Carlson, et al., 2019). For instance, in the Women's rights dance, the raised fist movement not only serves to communicate the role of power in data on perceptions of the role of women in society, but also, as described by one of the learners, seeks to generate an affective state that is "powerful." The consideration of music—i.e., the tempo and cultural references—were also forms of embodying affect to elicit certain audience responses, or what one learner referred to as "actual feelings." While meaning was made through the movements and dance phrases, the students' dances came together in a locus of meaning that was centered around the "*whole pattern of performance,* emphasizing structure, style, feeling, or drama" (Hanna, 2008, p. 493). This involved

creating new meaning of the data through the coordination between music, movements (individual and collaborative), performance, and experience of the audience.

This tension of balancing data representations with affective and aesthetic considerations speaks to a broader dialogue in the field of data literacy education and data visualization around humanistic data literacy (Lee, et al. 2021) that challenges claims of data as objective, neutral, and universal. In work by Klein and D'gnazio (2020) that connects feminist theory to data visualization, the authors note how embodiment and affect are too often not situated on par with more more quantitative methods of knowing and experiencing the world. In providing principles that encapsulate 'data feminism' the authors write, "the third principle of data feminism, is to elevate emotion and embodiment" (p. 95). Increasingly, data visualization approaches are exploring activating emotion, leveraging embodiment, and creating novel presentation forms to help people grasp and learn more from data-driven arguments (e.g., Rust, 2014). Learning experiences, such as creating and performing data dances from both a math and art disciplinary perspective has potential to center tensions on the role of affect in making claims about how the data should feel, how audiences engage in embodied and affective forms of sense-making through kinesthetic empathy, and the use of artistic dance practices that center this affective communication in data visualizations (e.g., music, gestures).

Conclusion & Limitations

The case study of dance and data demonstrated the potential of the embodied processes to develop learners' sensemaking of the data. Embodiment provided learners with an opportunity to develop a number sense as they deconstructed an understanding of the graphical representations. Further, their movements concretized their ideas about the data which grounded their numerical understanding in the real-world context of the data. Last, learners' creation of distributed representations across multiple learners facilitated collaborative sense-making about the data. In addition to embodiment, the performative practice had learners attempting to engage the audience to develop their own understanding of the data through their dynamic performances that were explicitly not neutral or objective. Although this study alludes to a number of important connections between data literacy and embodied learning, there were some limitations. First, the study was situated in the context of contemporary dance, limiting the range of embodied practices. Second, we ran into challenges in understanding learners' affective responses relying mostly on their verbal descriptions instead of embodied emotional responses during the curricular unit due to our limited ability to observe during classroom activities. Future research could more deeply attend to the contextualized instantiation of the data and dance practices. Additionally, we should continue to explore additional forms of dance to understand the breadth of embodied learning that can support data literacy while expanding the types of practices that can support learners in contextualizing and humanizing their data investigations.

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