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Exploring Set-Theoretic Practices of Youth Engagement in Connective Journalism: What We Lose in School-Mathematical Descriptions

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Synopsis

Analyzing youth video submissions regarding COVID-19 from KQED's 'Let's Talk About the Election' website, we explore the mathematics these youth engaged in through their submissions without creating any explicit connection to school-mathematical concepts or standards. Our focus is the students' construction of sets (e.g. sets of nurses, doctors, American workers), as a means of creating connection with voters and other media authors through Marchi and Clark's construct of *connective journalism* [22]. We observe these youth constructing sets of varying sizes and reflecting on how these sets are contextualized

within a larger political dialogue. We also attempt to rewrite part of one student composition using school mathematical symbolic logic, reviewing what in the student's message is no longer present in the school mathematical analogue and why. We conclude by encouraging practitioners to explore with their students various instances in which they can challenge the idea that numerical or school-mathematical symbolic writing is a superior means of communicating ideas.

1. Introduction

Leading up to the 2020 election, middle and high school students across the United States submitted video and audio statements to the KQED (a public broadcasting network based in California) "Let's Talk About Election 2020" website https://learn.kqed.org/challenges/election2020, henceforth referred to as "*e2020*" in the rest of the paper, sharing their thoughts on topics ranging from gene-editing and militaristic policing practices to the recent global pandemic. In this paper we share insights from an investigation of the videos young people submitted about the COVID-19 pandemic, with specific attention paid to how they related global and national events to themselves and their communities. We chose to explore the mathematics these students used to communicate their ideas in part so we could better understand how young people use their mathematical knowledge in contexts that they find both politically important and morally urgent; following [22], we refer to this genre as *connective journalism*—the proliferation, amplification, and composing of media related to current events and social issues through commentary on, or connection to, another piece of media, often by youth, as seen in social media, and incorporating calls to action.

Interest in the connections between mathematics and democratic participation often centers on concerns about quantitative skills regarding the interpretation of numbers, statistics, and data representations [34]. Less often does research focus on the mathematics of youth participation in, and the production of, civic discourse. Interested in this very possibility, we initially conducted an analysis of *e2020* media by examining *numeracy events*—the use of numbers in social contexts [8]. This analysis revealed a rich landscape of quantitative civic practices among the youth [16]. However, we noted along the way that in orienting the original analysis to the use of numbers, a profound underlying mathematics was overlooked.

That is, we found that the youth video authors, in their connective journalism, developed rich set-theoretic forms of reporting. In this paper we are not considering traditionally academic mathematical sets when exploring student work. As such, we define a set to be any collection of one or more tangible or intangible elements (e.g. my dogs, schools, the coronavirus). The focal students of this piece invoked sets and set relations in their discussions of how the COVID-19 pandemic affected them and those they cared about. Thus, in this paper, we focus on the choices youth video authors made in constructing sets and how they reflected upon the interactions of their sets.

The first question that we ask is, "What mathematics might we find in youth connective journalism beyond the use of numbers?" In unpacking their set-theoretic mathematics, we perform a thought experiment in which we attempt to capture one example in canonical, abstracted set notation. Following from that thought experiment, we pursue the second question, "What are the benefits and limitations of using existing school mathematical forms to codify the mathematics identified in youth connective journalism?"

In our initial analyses, we found set theoretic practices to be centrally engaged in connective journalism, as youth used a variety of rhetorical strategies to build layered, intersecting, overlapping, at times inclusive, and at other times mutually exclusive, conceptions of community. Attempting to map these practices using existing approaches to symbolic set notation revealed the complexity of the set construction undertaken by these young authors. In our effort to write youth connective journalism mathematics through school mathematical set notation we found ourselves losing much of the youth's strategy and nuance in the process.

This paper contributes insight into the inventive and ubiquitous mathematics used by the youth. In juxtaposing the salient set-theoretic mathematics present in youth connective journalism and the incommensurability of these set-theoretic practices with traditionally academic set theory, we likewise provide a critique of the capacity of current articulations of traditionally academic mathematics to recognize more expansive, creative, and human forms of mathematics. We conclude by expanding on the strategies we found in the youth civic compositions, and how those strategies can be leveraged and nourished without losing their mathematical power to often restrictive school-based mathematics settings.

1.1. Author Positionality

All authors are practiced in school mathematics, providing them some emotional security when moving between traditionally academic and non-traditionally academic mathematical spaces, a luxury the focal students in this piece may or may not have [21]. Likewise, we are embedded in universities, which are often considered to be the only centers of legitimate knowledge production [32]. We acknowledge a history of university-branded mathematicians referring to work other than their own as mathematics with this referent being given and received as a compliment. In contrast, it is neither our intention to academically "validate" youth connective journalism work by calling it mathematics, nor to suggest that the naming of it as mathematics in any way changes the intellectual value of their work. Rather, we intend to support others by noticing the ingenuity and brilliance of the young people whose videos we analyzed, and to extend our support to the youth broadly as they participate in the social, political, and mathematical world.

2. Background and Theoretical Framework

2.1. Mathematics and School Mathematics

We see mathematics as a social practice [5]. Mathematics is context-dependent (e.g. school, everyday, workplace, academic) and defined by the settings in which it is practiced [26, 33]. The mathematics practiced in schools is its own distinct form of mathematics. We define *school mathematics* to include the K-12 classroom as well as university mathematical practices. We unite these two communities of practice because we intend to highlight the political power university mathematics and mathematicians hold [27, 12] and index how that power is invoked in the content of K-12 spaces [30]. A school math version of a human activity and the human activity itself are not one and the same [6, 17, 36]. Thus, in modeling everyday activity using school mathematics, rather than creating a commensurate form, we in fact create a distinct one. For instance, one cannot separate the mathematics of, say, a baseball player from the baseball playing itself. The mathematics is the practice of baseball, and the practice *is* the mathematics. If the mathematical concepts of the baseball playing are reimagined through school math notation, one cannot assume the player would retain their mathematical fluency of the lived activity [33]. Nasir [28, 29] extends this work exploring why the fluency of young people in the mathematical practices of basketball, track, and dominoes is not reflected in school math measures of achievement.

The mathematics practiced outside of school, often called *ethnomathematics*, includes "practices such as ciphering and counting, measuring, classifying, ordering, inferring, modeling and so on . . . " [4]. These practices documented within ethnomathematics, however, emerge from a scholar coming very much within school mathematics observing nonschool mathematical activity as an "other" [20]. Commonly, the mathematics students perform outside of the classroom is defined as mathematics largely because it can be connected to a particular school mathematical practice [20], with this school mathematical lens limiting the forms, contexts, and people whose mathematical brilliance is recognized [19]. For instance, a student's act of arranging her garden may be seen as mathematics because the gardening can be mapped to a school mathematical geometry concept. However, it is not the school mathematical geometry which makes her gardening a mathematical act. Her mathematics is also the dynamic decision-making she goes through to choose which color flowers to use, her measuring of color preference against flower attractiveness to local fauna, her analysis of each of these against which plants thrive during which season, and so much more that an outside viewer could not see. Defining her mathematics only through school mathematical geometry concepts would omit a great deal of the depth and dimension of her knowledge.

In viewing and listening to the work these young authors submitted, we admired their mathematical brilliance, and wanted to share it using *their* mathematics, not a standard we could impose upon them. Much of the existing research on non-school mathematics is pursued with a school mathematical perspective, or with a goal of using that mathematics to further school mathematical concepts and understanding in the classroom [20]. While impossible to ever fully separate ourselves from our school mathematical conceptions, embedded in our ways of thinking from years of schooling, we endeavor here to explore the mathematics of the youth media makers without creating explicit connections to specific school mathematical practices or standards.

2.2. Connective Journalism

Young people today are less likely to subscribe to paper news publications or to view cable news broadcasts than in decades past, instead opting to receive most of their news from social media [1]. Marchi and Clark [22] developed a concept to identify how young people share news and information on social media called *connective journalism*. The authors explain that in connective journalism,

> "news" is not exclusively defined, explained, or spread by the industries or professionals historically associated with journalism, but rather by everyday people linked together online by their relationship to unfolding events or concerns ... when youth share information online (such as links, "likes," tweets, Facebook posts, Instagrams, or YouTube videos) about issues that are important to them, they are engaging in practices historically associated with journalism ... In doing so, they ... express their personal identities while also attracting others who share similar experiences or views (page 289).

With social media becoming a major news source, news is no longer solely defined and disseminated by major news outlets. Young people can claim a space in which their voice has journalistic value through their participation in connective journalism. While the purpose of traditional journalism is often the communication of a story (e.g., a neighborhood flood or a local business changing ownership), connective journalism foregrounds solutions-oriented practices (e.g., the neighborhood flood was caused by the ill-funded infrastructure which should be considered at the next city council meeting). Connective journalism is practiced by and for specific communities, building an individual and collective identity [22].

2.3. "Let's Talk About Election 2020"

We conceive of youth making and posting of videos on KQED's election platform *e2020* as a form of connective journalism wherein youth united themselves with their communities who were also experiencing the effects of local and national politics. Their videos addressed their own local and global concerns to a national audience surrounding a presidential election, thereby creating a network of youth voices to inform potential voters and national political decision makers about what should be done amidst the COVID-19 pandemic.

Broad themes within the COVID-19 media pieces we analyzed included many young people citing commonly understood pandemic best-practices (e.g. social distancing or mask wearing) as individual solutions, or using these practices to inform their ideas of larger social solutions (e.g., enforcement of mask wearing or social distancing). These youth encouraged their audiences to act based on their suggestions, to change their behaviors, or to vote for a political leader whom they believed had a sound pandemic safety plan.

They shared stories of their family members and friends affected by the pandemic, providing an opportunity for us to reflect on our own connections to these young people's experiences. In exploring youth mathematical practices in these youth-made videos, we contribute to work that explores activities that young people are already engaging in socially [7] with a new lens on what mathematics they use to forward their personal goals [16].

As we began the analysis of their civic compositions, we found that the shape of their political and personal statements was integral to the context each author developed. We learned from their work that a single measure could not convey what we saw. The video authors incorporated personal narratives as well as pleas for change based on specific aspects of the issue that uniquely affected them as individuals. The set theoretic moves these authors made existed between and across these two spaces, as the moves they made were informed by what they asked the audience to care about and who, from their personal experiences, they invoked into their stories. An exploration of their mathematics required us to center the narratives and explanations, as these narratives and explanations *are* the mathematics that these authors employed.

To open our analysis to the exploration of how the video authors connected to their audience and other media on the same topic, we chose to focus on the COVID-19 pandemic. We are interested in how the young authors engaged in creating a collective identity as a community sharing their experiences of the same event happening on a global scale. This allowed us to see how the authors created connections between the reaction of their home nation, the United States, to that of other nations, or to that of the entire world.

3. Methods

3.1. Data

By the time of the 2020 US Presidential election, youth had posted over 1,200 video or audio media segments to the *e2020* website. Of these, 52 were identified by topic as related to the COVID-19 pandemic. For the first phase of analysis, through which we identified the use of sets as a mathematical practice of interest, we worked with the full set of 52 media segments. In a second phase of analysis, we selected four media segments among them for more fine-grained analytic attention. These four media segments focused on the COVID-19 pandemic, and they were all video (not solely audio) files.

The four media segments represent perspectives from youth of different ages and from different states. The video authors are Mia, Emmet, Ava, and Cameron. Mia and Emmet are both middle school students from Illinois. Ava and Cameron are high school students from California and New York, respectively. The shortest video was roughly a minute and half and the longest video was over three minutes.

3.2. Analysis

Qualitative analysis [25] of the video transcripts allowed us to take into consideration the dynamic and highly individual mathematics practiced by the video creators. In the first phase of analysis we created content logs [9] of the videos, transcribing the words said and the images used in the video by the students. These student transcripts were organized into events based on changes in video (i.e. if the still image of the video changed, this marked a new "event"). Once this was completed for each media piece, we began a process of open coding [11] in response to our first research question, *What youth mathematics might we find in youth connective journalism beyond the use of numbers?*. Identifying the use of set creation and manipulation as a central organizing practice of these 52 pieces led us to the second phase of more fine-grained analysis of four videos.

In the second phase of analysis, we read over our written logs of the audio and images, outlining the sets invoked as well as other sets to which these might be mapped. Sets could exist across logged "events." Through another round of open coding and the production of analytic memos [11], we identified four strategies used by the students who constructed and interacted with these sets in the four focal videos: 1) use of representative elements, 2) relative size, 3) relationships between sets, and 4) reflection on set interaction. Through an event-by-event analysis, we verified that these events could be mapped to the strategies identified. It is likely that due to the small sample size, these four strategies do not reflect all of those possibly available in the data; in other words, we do not claim to have achieved saturation [15]. Rather, we acknowledge that the landscape of youth strategies of set construction and manipulation is part of the mathematics of connective journalism, which practice overflows what is captured here.

The third phase of analysis explored the question, *What are the affordances and limitations of using existing school mathematical forms to codify the mathematics identified in youth connective journalism?* The first author,

having practiced graduate level mathematics, began the thought experiment of attempting to map part of one student's statement to a school-mathematical space using symbolic logic borrowed from school-mathematical set theory. We created definitions and variables for each of the sets and elements we understood the student to be naming, listing them in a written statement in the order they were introduced by the student. We then analyzed what conclusions could be drawn from the school-mathematical work while following the rules and traditions of school mathematics, exploring these alongside the conclusions drawn from the student's original statement.

4. Findings

By participating in connective journalism, the focal students used sets to align themselves with other authors, those in their immediate community, and with more national spaces. They used sets to communicate their lived experiences and to compare and contrast them with those of their peers and the nation. They also reflected on the interactions between sets of their own construction and those of others. The students exhibited elaborate and dynamic tactics of set construction using 1) representative elements, 2) intention and care while handling the relative scope of their sets, 3) an understanding of the relationships between sets, and 4) thorough reflection upon the implications of their sets' interactions. Each of the strategies listed here will be explored in depth in the sections below using sample excerpts from student transcripts. These strategies were rarely mutually exclusive, and were more often than not found coexisting in student work. In each section below we highlight one strategy, although in most excerpts more than one strategy is present.

4.1. Use of Representative Elements

All four authors employed singular quantities as representative elements of larger sets in their videos, a strategy commonly used in public political statements (e.g. "one must be sure to wear a mask," "how can a mother provide for her children on minimum wage?"). These elements in student compositions were capable of serving more than one purpose depending on context, the most common two being to create a more detailed picture of the author and to further enrich the detail of the element's corresponding set. The myriad ways these representative elements were implemented are explored in

excerpts from the video transcripts. In Mia's case in this excerpt, the focal individual element is her mother:

> With **my mom working in a COVID ICU** during the global pandemic, she experienced lack of PPE, learning to ration and reuse PPE, the risk of running low on ventilators, and a concern of catching COVID from being around COVID positive patients.

Mia's mention of her mother allows the audience to learn more about Mia, the daughter of a healthcare worker during a global pandemic. Mia's mother's experience as a healthcare worker during the pandemic is situated in Mia's complete transcript not as unique, but as characteristic of other members of the set of healthcare workers during the COVID-19 pandemic in the United States. The audience can now begin to construct the set of healthcare workers as both including the mother of someone they've now "met" (Mia), and multidimensional in its many properties (i.e. concerns of catching an illness from patients, lack of adequate medical supplies). Mia connects her viewers to herself in a variety of ways wrapped up in both emotional and logistical consequences of the pandemic.

Emmet used a similar strategy, in his case invoking a political figure as his representative element:

> Every day, I see the constant rejection of overwhelming scientific proof, for example, this experiment by **microbiologist Rich Davis**, showing that masks result in a dramatic decrease in the amount of particles spread. Instead of trusting **professionals like Rich**, people would rather trust their own scientifically unfounded beliefs.

In his discussion of his disappointment in folks taking fewer precautions during the pandemic, Emmet cites evidence as justification for his frustration. Emmet credentials Rich Davis, a man whose expertise we can trust based on the set he belongs to — that of microbiologists. We see Rich's specific evidence of masks being effective tools to combat the spread of COVID-19 as one piece of a larger chorus of "overwhelming scientific proof." We are reminded that Rich's work is one piece of a larger set of "professionals like Rich" whom we should trust.

4.2. Relative Size

The students displayed keen awareness of how the relative sizes of their sets affected their sets' value, using both the potential of emotional connection inherent to individuals and smaller sets, as well as the political influence of larger ones. This pattern was almost always found in concert with the use of representative elements, with students explicitly amplifying individual stories using their connections to larger sets. In an example of this, Ava invokes her family alongside a larger set of American workers in an excerpt of her statements:

> Personally, I have learned from my mother that with the money workers received while quarantined and not working, many of them actually made more from unemployment than what their company was paying them regularly. This made it so that during quarantine it was easier for my family to keep up with bills, whereas in regular everyday life it's harder to do so. **This reveals a larger issue with how labor workers are paid compared to the work they do.** If **a worker** making most of the money for their family gets paid more while on forced leavesthan what they receive normally, how fair is their wage?

Ava points to her family's experiences as indicative of a "larger issue," explaining that her family's experience during the pandemic was a small piece of a larger repeating pattern of working families not receiving sufficient income before the pandemic. The COVID-19 pandemic has altered her family's life and made more transparent the aspects of the working American's life that may not have previously been visible to those outside the set of working Americans. Ava's statement is then made more individual, as well as more general, when she asks the audience to consider an arbitrary element of the set of American workers. She asks "if a worker" were to be living with the conditions her family lived with, would the audience consider those conditions fair? Ava makes use of a singular representative of a larger set to clarify the issue of unfair pay. Ava is likely not asking how the audience feels about one worker living with unfair wages. The individual representative is indicative of a larger set of all workers (incorporating the previous strategy of representative elements), and Ava makes use of the larger set's power while invoking the emotional power in discussing the individual. She asks us to connect with some*one*, and in doing so we connect with some*thing*.

In Emmet's case, we see the use of an individual nestled within a family alongside a rapidly growing set of COVID-19 cases. The story of Emmet's experience increases the emotional weight of the specter of case resurgence:

> Back in March, when the pandemic first started, we knew almost nothing about it. My mom is a doctor, and we had no idea what to expect, nothing like this had ever happened. My mom took to sleeping in our attic, eating dinner separate from the rest of the family, and having us wipe down any doorknobs [sic] she touched with bleach. It was a difficult few weeks, to say the least, probably some of the hardest of my life... I don't want a resurgence of coronavirus cases. **I don't want me and thousands of others to go through what I did back in March and April.**

Emmet lets his listeners into a very challenging time of his life, what he considers to be one of "the hardest of his life." His whole family dynamic had to be re-choreographed to defend against a virus about which we, at that time, had very little information. His story takes on the tone of a warning in final sentences here, with him asserting that he does not want the Coronavirus situation to worsen. He does not want "thousands of others," himself included, to experience what he did again. Emmet explicitly connects the rising case numbers, thousands of cases, to his experience with COVID-19. There is an implied awareness of the greater political power his story can hold when it is amplified to the thousands and spread across the country.

4.3. Relationships Between Sets

The students frequently invoked sets in close textual proximity and leveraged the relationship between those sets in their political statements. For instance, Cameron relayed the experience of a family member alongside others in the pandemic in his political expression:

> **My grandmother** works in the medical field and risks her own well-being every day **while other people seem to disregard the guidelines** set out by the CDC.

Cameron's grandmother is a representative of the larger set of healthcare workers "risking their well-being" during the pandemic. His grandmother — as well as any other members of the that set she brings to mind for the audience — is immediately contrasted with those "disregarding the guidelines set out by the CDC." The audience is then not only considering individuals

who disregard CDC guidelines, but those who disregard CDC guidelines *while those like Cameron's grandmother risk their well-being.* Cameron has shifted these individuals into a new set of his own design, taking advantage of how his grandmother and the individuals not respecting guidelines interact when placed in proximity with one another. The relative import of individuals electing not to follow CDC guidelines during the pandemic is given new magnitude, as are his grandmother's efforts as a healthcare worker.

Other students were able to apply similar set placement tactics using not only other sets, but shifting time. Emmet discusses the virus' changing properties as it moves forward and back several months:

> **Before [March 2020] the virus had seemed less real**, more like a news story. It wasn't really affecting us, was it? **Well, that sure changed quick**. In those first few months, everything locked down.

Emmet places the virus in time before March of 2020 and then immediately after March 2020, explicitly acknowledging the shifting magnitude of the effects of the virus on American lives as he moves through time. He acknowledges that a single set can change in magnitude depending on how, or when, it is situated, and makes use of this phenomenon in his opening statement. This ordering of events asserts Emmets conceptualization of the effects of the virus and his knowledge of its history, leveraging the likelihood that his audience had a similar experience and will agree with his assessment.

4.4. Reflection on Set Interaction

In their summarizing statements, each of the authors reflected upon the effects of the interactions of the sets they built, employing what can be recognized as both school and more everyday mathematical discourse. Consider, for example, an excerpt of the transcript from Mia's video:

> If our current administration had done a better job of acquiring and distributing supplies, disseminating information, and requiring consistent guidelines on a federal level in our country, we could have prevented the spread and been better prepared for the COVID-19 pandemic. As stated in CNN, the United States makes up only 4% of the world population and has about 8 million cases, making up 20% of the total worldwide cases.

> **If there would have been more unity on a federal level, some of those cases could have been prevented.**

The "federal level" is constructed in Mia's first sentence as involving the "current administration," the actions of which she intimates can be blamed for the rise in cases during the pandemic. The "unity" she discusses in her third sentence is then implied to be in some way related to the current administration doing a "better job." "Those cases" mentioned in Mia's third sentence reference her citation of a CNN statistic invoking several large sets, that of the United States population and COVID-19 cases, and global population and COVID-19 cases. Mia's third sentence blends a set of her own construction ("a federal level"), a relationship of her own construction ("unity"), and several sets numerically defined by a major news source ("these cases"). She incorporated an outside statistic into her reflection of the "current administration's" impact on the United States population (8 million Coronavirus cases), looking back and asserting that perhaps if things had happened differently, the case numbers might also have been different. Mia fluently moves between school and everyday mathematical discourse in her reflection. Her deft handling of the sets she invokes allows the audience to see clearly how the sets she brought together are related, and what that relationship means for the United States.

In a similar introduction of national statistics, Ava considers how her mother's knowledge (excerpt shown in section 4.2 on "Relative Size") is situated within a national issue:

> Of those still working during Covid, many have noticed a cut in pay and some have even lost their jobs. According to pewsocialtrends.org, 43% of adults say that they or someone in their household has lost a job or taken a cut in pay due to the outbreak... I conclude that with **the larger issue my mother brought up about how lower-income workers are treated financially and with the cuts in pay for people still working**, a change must come in the way we view lower-paying jobs and the way we provide them with financial aid.

Ava contextualizes her conclusion that "change must come" in her inclusion of multiple perspectives on the economic climate during the initial stages of lockdown during the pandemic. She characterizes first her mother's analysis of the situation as a "larger issue" about the treatment of low-income workers

and connects this analysis to the https://pewsocialtrends.org statistic ("the cuts in pay for people still working"). Her conclusion regarding the existence of these two trends is that the national conception of compensation earned by those doing low-income labor is incorrect and must be shifted.

4.5. Troubling "Set Theory"

The decision to refer to the work of these youth video makers as "set theory" was made with some hesitation. Ava, Emmet, Mia, and Cameron conveyed powerful messages through set manipulation, and theirs was an interesting theory of communication to highlight and explore. However, the words "set" and "theory" together are not without school math context. Set theory, for many, invokes the work of university mathematicians, bringing forth thoughts of Venn Diagrams, intervals, and other images characteristic of school mathematics classrooms. It is because of the prolonged involvement of school mathematical set theory in the lives of most United States mathematics students [14] that we were hesitant to mention "set theory" in reference to the connective journalism of the students in this study. However, we chose to challenge the intellectual authority of school mathematical set theory and maintain set theory as a defining term for the student work we explored.

The power set theory holds in school mathematical contexts [13], though, cannot be put aside entirely. In referring to the work of these young authors as "set theory," we have drawn an indirect comparison between the work done by the young people in this study and the work school mathematical set theorists do. The introduction of school mathematics into the space of the work of these young people brings with it the dominance school mathematics holds in public discourse, and the weight it carries in academic conversations. In an effort to problematize that dominance, and to understand the distinctions between the set theory of these young civic authors and the set theory of school mathematics, we attempted to recreate the statements of one of the young people using school mathematical language. We found value in exploring and analyzing the crudity of school mathematics as a tool in communicating the set theoretic ideas put forth by the students in these videos.

To this end, we have elected to explore Cameron's message about his grandmother, which we included earlier in Section 4.3 and which we will re-state below:

> My grandmother works in the medical field and risks her own well-being every day while other people seem to disregard the guidelines set out by the CDC.

The following represents a partial school mathematical approximation of Cameron's work.

> Let $g \in B \cap F \cap H \cap A$ where:
>
> $$\begin{aligned} B &= \{g_b : g_b \text{ is a grandparent}\}, \\ F &= \{g_f : g_f \text{ is related to Cameron}\}, \\ H &= \{g_h : g_h \text{ is a healthcare worker}\}, \text{ and} \\ A &= \{g_a : g_a \text{ is an at risk person}\}. \end{aligned}$$
>
> We then consider $D = \{d : d$ is a human being who disregards the guidelines of the CDC during the COVID-19 pandemic$\}$.

The above work begins by constructing some of the sets that Cameron did, and already there are several challenges with attempting to use school mathematical symbolic logic to represent Cameron's statement. School mathematical spaces do not permit ambiguous definitions [24], meaning that terms like "grandparent" would need clarification. However, definitions of "grandparent" may differ among readers, with the set definition of one reader not necessarily aligning entirely with the set definition of another reader. Additionally, elements of school mathematical sets are not meant to be valued differently by different readers. For instance, were a student to create a measure for the set of grandparents, the norm of a given element should not differ among readers (i.e., if a writer were to invoke some set A, the norm of an element a of A should be consistent for all readers [given a shared measure]). These norms should also hold steadfast to changes in author, meaning if Cameron invokes the grandparent set, the norm of any given element should be the same as if Cameron's mother had invoked the set. This is, however, not the case outside of school mathematics. Cameron's statement about his grandmother would be valued differently from that of his mother by different audience members depending on how they feel about Cameron, young people Cameron's age, those who look like Cameron, and countless other factors only distinct individuals could consider. In school mathematics, it is not the case that mathematics should be read and valued differently depending on the reader or the author. Similar issues abound and compound when adding on other sets in his statement (which become ambiguous in school mathematical contexts), and the emotional ties inherent to them and to Cameron.

The set of assumptions made when reading and writing within school mathematics have changed how Cameron's work is read. An audience's dynamically shifting qualitative assessments of Cameron, the ones listed above and more we cannot see, should not formally be legible in his school mathematics. The school mathematics above could be done by anyone with the requisite training. Cameron's statement could only have been originated by Cameron, and it derives its power from Cameron, the speaker, and from the differences between Cameron's distinct audience members. Cameron's mathematics communicates what it needs to precisely because it is *Cameron's* mathematics.

4.6. Discussion

In their civic composing, Mia, Ava, Emmet, and Cameron engaged with and created their own mathematics through their participation in connective journalism. The students built sets of themselves and those around them, uniting themselves with their audience and constructing their experiences in ways that allowed viewers to connect with their cause. Their engagement in an online platform and in connective journalism was an integral part of their set construction. The students' understanding of social sharing platforms informed how they communicated their concerns to a broader community, as was made clear by their frequent referencing of other media compositions in relation to their own ideas and their requests that viewers take action (vote) based on the information shared. In connecting their work to that of others and imploring viewers to act, the students drew explicit lines to their own media influence and made explicit claims of their potential influence to others.

The mathematics of their connections and conclusions proved to be beyond the reach of the language of school mathematical set theory. We were not capable of modeling their work using school mathematical principles alone, and we relied upon the constructions of their inventions to convey the intricacy of their work. The richness of their statements and deftness with which they handled quantities does not exist as a technique of school mathematics. Theirs was a hybrid of multiple discourses which created powerful discussions of what it is like to exist in the United States during the global pandemic.

4.7. Implications

By including more opportunities in mathematics classrooms for students to acknowledge the complexity of the mathematics they practice outside of the

classroom, practitioners can broaden student perception of what mathematics includes. Mathematics is more than operation, calculation, and measurement, and creating space for students to practice identifying mathematics in its many forms cultivates a classroom in which students can engage a space much like that which Gloria Anzaldúa describes in her essay "Flights of Imagination":

> Perceiving something from two different angles creates a split awareness that can lead to the ability to control perception, to balance contemporary society's worldview with the nonordinary worldview and to move between them to a space that simultaneously exists and does not exist. [2, page 28]

Anzaldúa's scholarship produced an important framing of the value in incorporating multiple perspectives, and how this can allow learners to move freely between spaces and control how they perceive and engage with material. Awareness of mathematics beyond school mathematics also creates space for opportunity to perceive both in different contexts. The authors of these videos participated in mathematics beyond what school mathematics is capable of capturing. They know and do a great deal of mathematics. Acknowledging and surfacing non-school mathematics in classroom settings could make new perceptions of knowledge accessible to students and to instructors. Likewise, youth composing through connective journalism might be nourished through set-theoretic play, mixing mathematical practices with those of civic writing to articulate constructions of solidarity in increasingly connected or expanded sets/communities.

We are not, however, suggesting that we give classrooms full access to student mathematical knowledge without complete student agency. In his analysis of ethnomathematical research, Alexandre Pais notes:

> One of the main features of ethnomathematics research consists in developing a critique of what is accepted as being mathematical knowledge, by the confrontation of knowledge from different cultures. The existence of different ways of dealing with quantity, space, and patterns [is] now well documented, and it is not possible to deny them. But, to pass from this acknowledgement to the aim of inserting it in a school setting in order to be disseminated through school education is problematic because schools are not open spaces of shared knowledge. [31, page 227]

As we explored in Section 4.5 on "Troubling Set Theory," school mathematics is a loud and dominating discourse, and the rules of its communication are often embedded in the classroom structure [37]. If we suggest that compositions like those explored in this paper be translated into formal symbolic mathematics, there is a risk, or rather a certainty, of these stories being overshadowed or reduced in their complexity. However, there may be an in-between, or third, space [18] wherein playful engagement with sets as representing changing communities with porous boundaries can serve the school-based goals of nurturing young people's learning while also challenging the purist boundaries of mathematics as a discipline. We believe that there may be space in the mathematics classroom to practice acknowledging where else mathematics exists, but we are not yet comfortable with using the mathematics discussed in this piece for purely school mathematical ends. To get to a place where student knowledge could be free from school mathematical dominance, that dominance must first be challenged.

5. Conclusion

Access to mathematics in different contexts does create an opportunity to question the dominance school mathematics possesses academically. As was shown in the example of Cameron's mathematics, school mathematics is not always a superior means of communicating ideas, despite claims within popular discourse to the contrary [3]. In Cameron's case, the assumed generality and universality of school mathematics limited the communicability of Cameron's individual feelings and ideas. When his ideas were communicated using school mathematical language (or "mathematized") a great deal of the possible conclusions which could be drawn from Cameron's video were no longer accessible. The problems encountered in mathematizing Cameron's statement invite opportunities to question school mathematical dominance. One would encounter similar problems attempting to read and write any other student's non-school-mathematical writing using a school mathematical lens.

On the other hand, seeking out opportunities to question the dominance of school mathematics could create space for non-school, non-numerical mathematics to be publicly valued in the classroom equally alongside school and numerical mathematics. Students could be given time to see more varied forms of their knowledge as worth mathematical energy and introspection.

They could develop their skills to critique and explore what it looks like when formal logic or numerical mathematics is not needed or when their work could be better served by qualitative data.

While working on this paper, we had the privilege to experience the mathematics Mia, Emmet, Ava, and Cameron enacted in their work without the limits of traditional school mathematical assessment in our analysis. Future work could endeavor to understand what else students can do and find when given this same privilege in their own explorations.

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