

2023

College Students' Numeracy Events in Discussing Public Issues

Samuel L. Tunstall

Trinity University, stunstal@trinity.edu

Follow this and additional works at: <https://digitalcommons.usf.edu/numeracy>



Part of the [Science and Mathematics Education Commons](#)

Recommended Citation

Tunstall, Samuel L.. "College Students' Numeracy Events in Discussing Public Issues." *Numeracy* 16, Iss. 1 (2023): Article 2. DOI: <https://doi.org/10.5038/1936-4660.16.1.1429>

Authors retain copyright of their material under a [Creative Commons Non-Commercial Attribution 4.0 License](#).

College Students' Numeracy Events in Discussing Public Issues

Abstract

An important consideration in the design and development of numeracy-focused coursework is ensuring that one meets students where they are with respect to both their mathematics background and their existing numeracy practices in relation to public issues. The latter consideration is especially important, given that students already think about such issues in their daily lives, long before we use them as a means for motivating quantitative exploration in the classroom. In this article, I report on a qualitative study of eight college students' numeracy events—that is, events mediated in some way by quantification—when reasoning in focus groups with three distinct media artifacts concerning public issues. Core findings from the work are that (1) students in the study leveraged their identities and background knowledge to think about and discuss public issues (which corroborates existing research), and (2) numeracy events, when they did occur, primarily consisted of one-time references to or acknowledgements of quantitative information in the article, rather than active use or manipulation of such information. I end by discussing implications of these findings as well as future avenues for research.

Keywords

numeracy, quantitative reasoning, quantitative literacy, literacy practices, numeracy practices, numeracy events, public issues

Creative Commons License



This work is licensed under a [Creative Commons Attribution-Noncommercial 4.0 License](https://creativecommons.org/licenses/by-nc/4.0/)

Cover Page Footnote

Samuel Luke Tunstall is Director of the Quantitative Reasoning and Skills Center and Lecturer in Mathematics at Trinity University in San Antonio, Texas. He is also the current President of the National Numeracy Network.

Introduction

Though the labels for general education graduation requirements for mathematics differ (e.g., quantitative reasoning, quantitative literacy, or simply mathematics), a common rationale for requiring students—particularly those who are not STEM-intending—to complete such a course is so they might learn mathematics or quantitative skills that they can draw on for use in their professional, day-to-day, or civic lives (Steen et al. 2001; Hamman 2017). A common setup for a numeracy-focused course, in particular, is for students to learn skills related to mathematics or statistics (e.g., proportional reasoning, basic data analysis and visualization) and to connect those skills with relevant issues. While some research exists concerning how students in numeracy courses reason with personal or socially relevant issues, there is a need for research that specifically considers the types of numeracy events students might engage in when reasoning with such issues *outside* of a formal mathematics classroom setting (Baker 1996; Craig and Guzmán 2018; Agnello 2021). Note that a numeracy *event* is an event (whether spoken, written, or thought) that is mediated in some way by quantification; a numeracy *practice* is a patterned way in which an individual (or community) uses quantification. Insofar as numeracy events form a basis for the broader numeracy practices that many educators seek for students to engage in (e.g., engaging critically with graphs in the news), it is important that we understand the nature and types of numeracy events that students already tend to engage in. With that idea in mind, the purpose of the present study was to explore how a small group of undergraduate students engaged with public issues—a specific context for numeracy practices—in a focus group setting. By public issues, I mean issues of likely interest to a given community and that potentially affect that community's functioning or well-being, such as a county vote on school funding or a neighborhood debate on allowing electric scooters on sidewalks.

Building from previous work examining how students in quantitative literacy courses reasoned with public issues during semi-structured interviews (Tunstall et al. 2016; Tunstall et al. 2018), this study explored the following research questions:

1. How do students who have the option to enroll in a quantitative literacy course discuss public issues in a focus group setting?
2. Do numeracy events occur as they articulate their reactions?
3. If so, what are the characteristics of these numeracy events?

Note that I use Baker's (1996) and Craig and Guzmán's (2018) notion of numeracy events here to help identify (though not guarantee, as discussed later) numeracy practices. Exploring questions such as these may support work in the field of numeracy education by (a) specifically attending to ways students think about issues in informal settings (i.e., outside of a classroom context where they might be expected to use quantitative reasoning); (b) considering the nature of

numeracy events in such settings, which could provide educators with insights into how to build from such events in the classroom; and (c) utilizing a practices perspective for research (which is nascent within the US numeracy community). Note that, though I do not focus in this study on the *soundness* of students' reasoning during numeracy events (if applicable), I recognize that this is an important area of concern and encourage interested readers to use such a lens in reading this article if desired.

The next section of this paper begins with a brief review of literature concerning public issues and numeracy practices. In that review of literature, I elaborate on existing work at the intersection of numeracy practices and public issues, specifically focusing on what we know about how individuals use quantitative reasoning (or not) in the consideration of everyday topics, and more specifically public issues. I then present the study's data collection and analysis methods. Then, I elaborate on these two key results from students in these specific groups: (1) students leveraged their background experiences and knowledge in articulating standpoints on public issues, and in relation, students actively expressed critiques and questions as they engaged with the three artifacts; and (2) numeracy events, when they did occur, were primarily centered around students' acknowledgements of the importance of numbers, more so than their active articulation in building on that importance through group conversation. As I will discuss later, an implication of (1) is that when discussing public issues in mathematics courses, it appears to be important to use an interdisciplinary lens and to elicit students' preexisting beliefs and understandings about the issue at hand. The result of (2) indicates that there is both promise in, and a need for, structured means of exploring issues through a quantitative lens with students in classrooms centered on quantitative literacy.

Numeracy and Public Issues

The message presented in many calls for numeracy or quantitative literacy is that because the world of the twenty-first century is “awash in numbers” (Steen et al. 2001, 1), it is imperative that our citizenry be numerate for their own sake, that of their communities, as well as for democracy itself. While there are many diverse contexts in which one might practice numeracy (e.g., a grocery store, browsing social media), a common context of interest to those involved in numeracy education is civic life (Steen et al. 2001; Erickson 2016; Hamman 2017; Briggs 2018; Mellow 2018; Karaali 2020). Indeed, with quantitative rhetoric saturating advertisements, political discourse, and many of our everyday conversations (Porter 1995), this interest is not surprising. I argue that, if we seek to talk about public issues with students in a numeracy classroom, it is important that we understand how students tend to discuss public issues outside of the classroom,

given that—when in the classroom—students may behave differently to appease the instructor or to satisfy course requirements.

Indeed, prior research suggests that the ways in which students interact with quantitative or mathematical information outside of classrooms is often different from how such interaction might be supported or taught in a classroom setting. For example, research from Carraher et al. (1985) found that street vendors in Brazil could perform complex mental calculations using procedures distinct from those taught in school; those same vendors performed significantly worse when completing those problems if required to use equivalent formulations typical to those in school mathematics. In a different context, Murtaugh (1985) found that problems encountered by grocery shoppers—those which could be formulated as basic arithmetic calculations—were not viewed by the shoppers as such, but rather were approached in manners consonant with the situation and the specific problem the shoppers desired to solve. To date, though, there is a paucity of work concerning *how* individuals use numerical information or quantitative reasoning in interacting with public issues (whether alone or in a group setting) outside of a classroom setting. Moreover, while that research does help us in understanding the *how* of my first research question, it does not specifically address individuals' interactions with issues through a numeracy events lens—the subject of my second and third research questions. I make this claim from having searched for literature in Google Scholar with the following terms in the abstract (using pairs of terms, with one from the first three and one from the last three, for a total of nine searches): numeracy, quantitative literacy, quantitative reasoning, public issues, decision making, and deliberation.

Extant research concerning numeracy and interaction with public issues comes from the last eight years and primarily from individuals studying decision making and psychology. Importantly, researchers have continually found that—concomitant with using numbers—individuals tend to engage in motivated reasoning when examining public issues; that is, individuals are likely to make arguments in favor of what they want to believe (Kunda 1990). Specifically related to numeracy, in a study of the interaction between numeracy scores (as measured by a multiple-choice test and Likert-scale questions) and hypothetical decision-making when presented with data on various topics, Kahan and colleagues (2017) found that individuals with higher numeracy scores were more likely to make correct inferences when the topic was of seemingly little public importance (in this case, skin rashes); however, when presented with data on the controversial topic of gun control, most participants engaged in motivated reasoning, making inferences aligned with their existing political beliefs, with the more numerate individuals using quantitative reasoning selectively to reach their conclusion. Nurse and Grant (2019) found similar results in the context of study participants' decisions surrounding climate change. In contrast, in more recent research, Shoots-Reinhard

et al. (2021) found that verbal skills, not numeracy skills, were the best predictor of polarization in relation to public issues, suggesting that quantitative reasoning skills may not be the primary culprit for polarizing beliefs stemming from ability. Consequently, to those authors, “to reduce polarization, greater emphasis should be placed on understanding how to convince people to integrate ideologically-inconsistent information into their knowledge networks” (Shoots-Reinhard et al. 2021, 14). This statement is useful for teaching in a host of domains—including in a numeracy-focused course, where public issues are a common context for quantitative explorations.

While valuable, this research from psychology and decision-making studies has (by necessity) been done using large samples and purely quantitative measures. While such research provides us with potential patterns we might expect among the general public in thinking about public issues, it does not capture the nature of numeracy events as (or if) they occur in individuals’ reasoning. Moreover, it does not tell us what types of evidence individuals gravitate toward when interacting and discussing artifacts that contain a variety of information formats (e.g., headers, pictures, graphs, text, and author information). The research that I do here allows for individuals to respond in a variety of ways (e.g., on paper, and through group discussion) to artifacts, and so opens up the possibilities of what we might learn from participants in the research process.

Outside of this work in psychology and public policy, the only other study found in my search concerning numeracy and public issues is the one from which the present study builds. Stemming from a desire to better understand how students in a quantitative literacy course at Michigan State University (MSU) were *already* thinking about public issues before taking the courses, in 2016 I engaged in semi-structured interviews with five students enrolled in the course. In the interviews, we discussed their reaction to several media artifacts (e.g., a tweet, newspaper article, or a video). The specific question that we explored as part of the study was the following: How do the students in our interviews reason quantitatively—if at all—when asked to articulate their reactions to artifacts concerning public issues? In our analysis, we found that students discussed the artifacts in a variety of ways, sometimes using quantitative reasoning and other times discussing the issue through a completely different lens. That is, the extent to which students referenced or used mathematics or quantitative reasoning varied from student to student (some not using it at all). For example, two students discussed the legality of stop-and-frisk, whereas one student talked about its disproportionate impact on certain groups. Moreover, we found that students tended to leverage their background experiences—whether related to ethnicity, age, or religion, among other things—to argue certain standpoints on public issues (Tunstall et al. 2018).

We did not formally use any constructs from psychology (e.g., motivated reasoning) to analyze the interviews, but the results of our study did suggest that

individuals' reasoning with public issues were informed by what they thought of the issue before coming to participate in the study. There were also several areas for improvement in that study. One aspect of the design was that students were discussing the public issues with just me, rather than with peers. Discussing issues with me, rather than with a peer, could lead students to respond in ways that they believe I would approve of as a researcher. Of course, that problem does not go away with a focus group, but I believe it is mitigated by emphasizing to students that the group is meant to be a conversation among peers. Another drawback with that study is that students did not have space to write or collect their thoughts before discussing the issues; they also did not have the opportunity to influence our analysis after the interviews had taken place. The present study builds upon that study by explicitly using a numeracy practices and events framework, and by improving the methods used for collecting data.

Taken together, this existing work in anthropology (Murtaugh 1985), mathematics education (Tunstall et al. 2018), and psychology (Carragher et al. 1985; Kahan et al. 2017; Nurse and Grant 2019; Shoots-Reinhard et al. 2021), suggests that students' prior experiences and beliefs would likely contribute to how individuals discuss public issues in focus groups discuss. What it does not tell us, though, is how we might expect numeracy events to occur as students discuss issues in a group setting. As part of the previous study that I engaged in, only some students (and for some artifacts) used quantitative reasoning (and thus broached numeracy events) when thinking out loud about the artifacts. Now, in a group setting, it remains unclear what will happen if one student begins a numeracy event for others to then build on (or not). There are added layers of complexity that this study provides by having students engage in focus groups and by generating multiple forms of data (to be discussed below).

Method

The following research questions guided this study:

1. How do students who have the option to enroll in a quantitative literacy course discuss public issues in a focus group setting?
2. Do numeracy events occur as they articulate their reactions?
3. If so, what are the characteristics of these numeracy events?

To examine these questions, I formed focus groups of students (Liamputtong 2011) and followed a semi-structured, think-aloud protocol (Thelk and Hoole 2006). As noted by Liamputtong (2011), a focus group methodology is useful in "exploring and examining what people think, how they think, and why they think the way they do about the issues of importance to them without pressuring them into making decisions or reaching a consensus" (7). Though I could not guarantee that the artifacts I chose would be of interest to the students, I did (as discussed

below) intentionally choose topics that I thought would be of importance to college students in Michigan. The purpose of having students in focus groups, rather than engaging in conversations one-on-one or having a formal group interview, was to simulate the reality that we rarely think about public issues in a vacuum. While the focus group method does lead to a potential loss in the depth of information obtained from any single respondent, the benefit is that it captures what is more likely to occur in a deliberative setting. In relation, another rationale for having focus groups was that students might be more comfortable in expressing their feelings amongst individuals whom they view as peers, as opposed to me, whom they may view as a figure with power (Madriz 2003).

Participants

Insofar as there was no intention in this study to generalize from the focus groups, and I wanted to make sure that all students were compensated for their time, I chose to hold two focus groups with four students in each group. Having obtained approval for the study from the Institutional Review Board at MSU, in Summer 2018 I worked with MSU's Registrar's Office to obtain a list of students who were enrolled in their first mathematics or statistics course in Fall Semester 2018 and had not completed the University's mathematics requirement (this means students placing out of mathematics altogether were not included in the selection pool). The rationale for this delimitation of the selection pool was that I did not want to include students who may have already been in a college course focused on mathematics and public issues. Using the Registrar's list, I reached out to students via email, offering them a small gift-card for their time (a maximum of two hours), and telling them that we would be discussing public issues for a research project. Given the large student body enrolled at MSU, it did not take long to have enough students interested, and so I scheduled the two groups for the days preceding the start of the Fall 2018 semester. In Table 1 below, I provide a list of the students (using pseudonyms). The column "Self-described identity markers" is based on information I asked of students through a form at the end of the focus group; I expand on the rationale for that request when discussing the protocol later.

As shown in Table 1, participants varied in their program of study and the year they were in at MSU. Next, I discuss the characteristics of the focus groups, including the protocol used and the data collected.

Focus Groups

Protocol. For both focus groups, the meeting began with a few minutes of informal (and unrecorded) time for folks to get to know one another and to have light refreshments. During this time, I explained to students in general terms the purpose of the study, noting that I would provide more information—notably my research questions and positionality in relation to the work—after we had finished talking

Table 1
Focus Group Participants

Group	Name	Major/minor	Year	Self-described identity markers
1	Pashiel	Human Biology	Sophomore	Logical, liberal, and open-minded
1	Alexa	International Relations	Junior	Victim, phoenix, and advocate
1	Layla	Political Science/African Studies	Junior	Black, woman, and socialist
1	Savannah	Experience Architecture	Sophomore	Christian, female, and student
2	Teta	Nursing	Sophomore	Female, activist, and Rwandese
2	C	Theater and English Education	Junior	Liberal, feminist, and environmentalist
2	Jayla	English	Sophomore	Female, Black, and Detroit native
2	Ash	Political Science	First year	Passionate, gamer, and Michigan native

about the public issues. Once recording began, we went around more formally to introduce ourselves. We then went through three cycles of examining and discussing a media artifact. For each cycle, students (1) read or watched the artifact alone, (2) independently filled out a section on a Google Form, and then (3) discussed the artifact with the whole group.

In relation to (1), students were instructed to annotate their copy of the article by circling things they found interesting or important, and by writing down any questions that came up; for the video, students had a blank piece of paper to write down their thoughts. Students knew that their work would be collected and later scanned. For (2), students used a laptop or tablet to answer the question, “What’s your general reaction to what you’ve just read or watched? Please include as much detail as you can—your response does not have to be polished or ‘academic.’” Following (1) and (2), our group share-out consisted of students first telling the group what they wrote down on the Google Form (each one in turn, going in a random order, so a different person spoke first for each artifact), and then discussing a question I had prepared specific to the artifact itself. After going through three cycles of artifact discussion, students independently filled out a final Google Form and received their compensation. This final Google Form allowed for me to confirm students’ fall semester mathematics enrollment and to ask for a few identity markers that were important to them. I explained to students in person that that might be helpful for me in thinking about why they responded in the ways that they did. I then told students that, if possible and they had time, I would be following up with them once I had completed my analysis to see if they had any questions, concerns, or suggestions about the ways I had interpreted their participation.

Media Artifacts. As noted above, there were three artifacts that each focus group examined: two articles and a news video. Students were presented the artifacts in full, with no information (e.g., source, date, author, etc.) excluded.

The first artifact is an article from *Mother Jones* (Sonde 2018) concerning a recent lawsuit between Monsanto and a man who had been diagnosed with terminal cancer; the article’s title is, “The Roundup Chemical Found Responsible for Cancer Might Also Be in Your Cereal.”¹ I chose the article because it’s short (less than one front-and-back page printed), it takes a clear stance on the topic (as evidenced through opinionated statements throughout), it has the potential for students to use quantitative reasoning in discussing it (there are several statistics used as part of the argument), and it would likely be of interest to students. Based on personal experience, I have found that college students talk about the safety of their food; given that this article covers a potentially controversial topic, I thought that it might generate hearty discussion. As part of our group share-out, the specific prompt that I posed to the group was the following: Should we—the general public—be concerned about “glyphosate” in products like cereals? What about in products like RoundUp? Explain why or why not.

The second artifact is a three-minute video from *Vice News* entitled, “Charter vs. Public Schools and the Kids in the Middle.”² In the video, correspondent Gianna Toboni travels to Michigan to discuss charter and public schools with select parents and students, a school administrator, and the husband of the now former U.S. Secretary of Education Betsy DeVos, Dick DeVos. Similar to the first artifact, I chose this video because it is short, it has a clear message, and its setting would likely engage the students in my focus group, given that many of them are from Michigan and have likely heard about Betsy DeVos in both local and national contexts. There are also a few statistics provided in the video that students might call attention to in their discussion. The prompts I asked in our group share-out were the following: What are factors that come to mind when you think about whether charter schools are a viable option to send one’s child to? Would you send your child to a charter school? Why or why not?

The last artifact is a brief *Fox News* article titled, “White Police Officers Don’t Unfairly Target Black Suspects, Study Says” (Derespina 2016).³ Like the first two artifacts, I chose the third artifact because it’s short, contains a clear stance, and features multiple statistical statements that students might utilize in engaging with it. Given that it covers the topic of race and crime, I predicted that it might be the most provocative of the three (though notably, I did not know the race of students

¹ <https://www.motherjones.com/environment/2018/08/roundup-monsanto-glyphosate-cheerios-quaker-oats-cancer-1/>

² <https://www.youtube.com/watch?v=cVYUTkYW4u4>

³ <https://www.foxnews.com/us/white-police-officers-dont-unfairly-target-black-suspects-study-says>

whom I would be working with before meeting them in person). The prompt I asked in our group share-out was the following: Do you believe that police officers should be required to wear body cameras? Situate your response in some way within the context of this article.

As one can discern from the protocol and the artifacts that I chose, a key aspect of the focus groups was that students were not prompted to use quantitative reasoning; the rationale for this was that I wanted to see how students would think about issues if they encountered them in a more realistic context outside the classroom or focus group space. If prompted to use numbers or quantitative reasoning in the focus group, students might respond in ways potentially different from how they might in daily life, as has been noted by others (e.g., Boersma and Klyve 2013). Of course, such an extrapolation (from a focus group to “daily life”) is impossible here, and I do not intend to suggest that the results can be divorced from the contexts of the focus groups. Nonetheless, I still aimed to simulate the ecology in which we think about public issues.

Data Collection. Taken as a whole, the data that I collected as part of the study included: (1) audio of the entire focus group, (2) students' individual annotations of each artifact, (3) students' Google Form responses to each artifact, (4) students' responses to final questions on the Google Form (concerning the identity markers and any final comments), and (5) responses to emails that I sent in following up on the study. Note that the group conversation in response to each artifact is captured through (1). Students' individual sense-making or private views (that they were willing to share with me) were captured in (2) and (3). The purpose of (4) was to gather some information about what students thought was important about themselves, and the purpose of (5) was to see if students had any comments or questions about the way I had analyzed the data, discussed in further detail below.

Analysis

The three research questions guiding this study invite a description of what occurred over the course of the two focus groups. Upon scanning students' annotated articles, compiling students Google Form responses, and transcribing the audio files of the focus groups, I read each of them multiple times. I then wrote a summary memo for each focus group, and a summary memo of each student's participation in the focus group. The summary memos for the whole group outlined my understanding of how the group went (e.g., students' engagement) and general reactions they had to each of the three artifacts; they were approximately one single-spaced page. As an example of what I mean by engagement, I noted that for the first focus group, students were initially quiet, seemingly because they had not met me nor each other before; I further went on to note that students interacted with each other more as they noticed connections with one another (e.g., I asked students what classes they were in before the formal commencement of the group). As an

example of what I mean by “general reaction” to the artifacts, I noted that the first group let out an audible sigh when they saw Betsy DeVos featured in the Vice News video.

Summary memos for the individuals also included a short note about the student’s engagement (e.g., Was the student outwardly enthusiastic or passionate about a given topic?) but focused more on my understanding of how students responded to each of the three artifacts, as evidenced in their in-group discussion and their Google Form responses. For example, for Savannah and the RoundUp article, I wrote:

In the group discussion and in her annotation, Savannah expressed concern about her consumption of certain foods in the past year that appeared to be related to Cheerios, such as oatmeal and breakfast bars. She stated on the Google Form that she sometimes felt she could taste the chemicals on her food, and she did not necessarily trust companies to keep her safety in mind. Savannah noted in the Group Discussion that her grandmother had always told her to rinse off certain foods before eating them due to the presence of pesticides on them.⁴ Taken together, she expressed uncertainty about what this article meant for her future food consumption.

I included in the memo numeracy events that I had identified, given that (as discussed below) I necessarily interpreted students’ thought processes in order to identify them. They were approximately half of a single-spaced page each. I emailed a copy of the individual and group summary memos to each of the eight students in December 2018, asking that they briefly check it to see if they had any questions or suggestions about what I had written. Five of the eight students responded that the memos looked fine based on what they remembered, and three students did not respond.

The next stage of data analysis consisted of examining the memos, generating themes, and then revisiting the original data to look for any disconfirming evidence in relation to those themes. I discuss each of these steps below.

To initially arrive at themes, I examined the memos and wrote out—for each artifact and each student—what came across as characteristic of, or essential to, how students responded to the specific artifact in group discussion and in writing. The reason for using the memos as the primary source for generating themes is that they captured, in one place, all the evidence sources related to students’ responses. That is, they combined a student’s annotation, Google Form response, and group discussion participation into one central source from which to look at the student’s response to the artifact. Continuing with the example of Savannah and the first artifact, I wrote that characteristic of her response to the artifact was the following: Suspicious of companies; Unsure of some topics in the article; Discussed family member’s experiences. I acknowledge that what I viewed as characteristic of a

⁴ Note that RoundUp is an herbicide, not a pesticide. I do not correct this misidentification in students’ responses.

student's response may not be exactly how the student would have self-described their response. With that said, by sending the summary memos to students, I did aim to reduce the possibility of inaccuracies that might emerge in subsequent interpretations. Savannah was one of the students who responded and noted that she did not have any concerns about the summary memo from her participation.

This reduction in data allowed for me to create a table of characteristics of students' responses, which are provided in the Appendix. After having identified these characteristics, I looked for similarities among them. For example, for many students their prior experiences with family informed their responses; another characteristic was prior experiences more broadly with respect to race. Both of those characteristics (in addition to others) could be grouped under the larger category of "Prior experiences," which is why I used that label as a broader theme. I am aware of the possibility that different researchers may have developed different categorizations of the data. I acknowledge this in my analysis by discussing the nature of students' contributions as specifically as possible so that their individuality is not lost (e.g., highlighting race, as opposed to just referring to it as part of a student's background). Furthermore, though I aimed to examine only those memos to come up with these themes (i.e., to let the themes emerge from the data of this study), I was nonetheless inevitably influenced by the prior study (Tunstall et al. 2018) that I had completed with colleagues. To reduce the impact of that study on this analysis, I avoided reading that work (or its associated data) for three months leading up to this analysis.

With respect to the second and third research questions, data analysis was informed by Baker's (1996) and Craig and Guzmán's (2018) definitions of a numeracy event, which is an event mediated in some way by quantification. In light of Baker's (1996, 81) notion that, in a numeracy event, quantification is "integral to the nature of the participants' interactions and their interpretive processes," there was necessarily some interpreting that I had to do to identify numeracy events. This is why it was important that I include numeracy events in my memos to students. In going through the data generated from the focus groups, I identified numeracy events in relation to their source (e.g., an annotation of the news article, or a student's statement in the group discussion), and then considered moments before and after that source that seemed to have an impact on student's writing or the group's conversation. For example, I noticed in Pashiel's annotation of the *Mother Jones* article that she had circled two quantities, and that she followed up by briefly alluding to the discrepancy between them in her written response; this was a numeracy event, as it was an instance of quantification influencing a participant's interpretation of an artifact. Identifying this in the data triggered me to make sure that I checked to see if she followed up on this in the group discussion of the artifact (which, as I will discuss below, she did not). Note that I did this for all participants

and all numeracy events. These identified events served as the unit of analysis which I describe in the Findings section.

Note that, based on the definition of a numeracy event, numeracy events are not always observable, as an event can be mediated by quantification without there being a remnant of that mediation in the form of audio, video, or text. For example, a student's reaction to the RoundUp article could be heavily influenced by a statistic mentioned at the beginning of the article, and yet the student might not state that in their subsequent individual reflection or in the group discussion. Hence, a limitation of the approach outlined above in identifying numeracy events is that I could not ascertain events mediated by quantification that did not manifest in students' writing or audio through an explicit reference to quantitative information. For example, a student may have read a passage containing data which then influenced their response in a specific direction; I do not capture that as a numeracy event if the response itself did not include quantitative information. Though this limitation is nontrivial, I did aim to circumvent it by providing students numerous opportunities to voice their interpretations of (and responses to) the artifacts. An additional limitation to bring up here is that numeracy events are not the same as numeracy practices, which are patterned (or repeated) things individuals tend to do in numeracy events. We ostensibly discern practices through events, but from these data alone I cannot make claims about students' actual numeracy practices; I can only make inferences about what those practices might be, if we assume that students do such things regularly or in similar contexts in their day-to-day lives. An open question in the numeracy literature is how one might actually demonstrate or "prove" that an observed behavior in a numeracy event constitutes a numeracy practice. Finally, I should note that my interpretation of the notion of a numeracy event is somewhat different from that of Agnello (2021) who, in a recent analysis of numeracy events in a corpus of Newsela texts, viewed the artifact itself as a site for numeracy events if there was quantification present; here, I only view interaction with an artifact as a numeracy event if the human-artifact interaction itself clearly demonstrated (in some way) that quantification was a part of the participant's interpretative process.

Findings

I have outlined the results from the study by research question. Within each research question's section, I organize the discussion by themes that emerged from analysis of the data. Note that I do not claim that any emergent themes are to be generalized for these students to other contexts, or from these students to other students. I am referring to the specific students in this study discussing the issues from these focus groups. I encourage the reader to make sense of the data dialectically in relation to their own experiences.

Question One: How Students Discussed Public Issues

Leveraging Prior Experiences. Students' prior experiences had a salient impact on how they talked about the three public issues in writing and with peers in the focus group. This theme was robust across the eight students and the three artifacts. Where prior experiences had left marked impressions, students' views appeared to be stronger and more adamant.

With respect to the first artifact (concerning glyphosate), students' existing experiences and understandings of chemicals, foods, and cancer influenced how they responded to the issue discussed in the article. For example, Alexa made clear in her annotation (Fig. 1), her writing, and her dialogue in the focus group that she was not in favor of the use of pesticides in foods: "If you ask me, pesticide consumption is just as bad as eating paint or super glue or hand sanitizer."

The EPA, which considers Roundup "not likely to be carcinogenic to humans," deems an exposure rate of 2 milligrams per kilogram of body weight per day acceptable. EWG, however, calculates that the highest permissible level of exposure, based on the Food Quality Protection Act's margin of safety for childhood risk, is 0.01 milligram per kilogram of body weight per day.

any is unacceptable

Figure 1. A snapshot of Alexa's annotation of the *Mother Jones* article on glyphosate in food.

As shown in Figure 1, her comments in the focus group aligned with those from her annotation of the article. Though Alexa did not describe why she had the views that she did, note that they were likely influenced by prior experiences (i.e., not just the present article itself), given that the article (on its own) would not have led her to make the comparison to paint or super glue.

Pashiel appeared to leverage her positionality as a working-class person in discussing the article with the group, stating: "I wonder why they don't care about our health. Do they put pesticides in cereal because they know that working-class people eat it, and they want to do everything in their power to kill us slowly?" Like Pashiel, C also expressed the view that the corporations in the article were engaged in negligent behavior. C, having had prior encounters with this topic before, also noted (in her written reflection) that this was not the first time that she had read about Monsanto:

I dislike Monsanto as a corporation due to their shady business deals involving GMO seed and their fellow farmers. I automatically identify Monsanto as the evil-doer in this story, I do not believe their statements that the glyphosate is safe, I think that there should be tighter regulations on the types of pesticides used on crops. While *Mother Jones* is not (in my opinion) a credible news outlet, I do believe that the topic of pesticides is being filtered out of our news along with other climate reality issues that are being forced out of public scrutiny in order for the post-Trump administration to continue to profit while the environment is destroyed. There is an obvious money link between these corporations when scientific research is discredited in order to continue to make profit.

C not only held a strong conviction about Monsanto, but also utilized her understanding of the current political climate, as evidenced both in the quote and in her written in annotation of the article (Fig. 2).

Agency may not — Past-Trump EPA

The EPA, which considers Roundup "not likely to be carcinogenic to humans," deems an exposure rate of 2 milligrams per kilogram of body weight per day acceptable. EWG, however, calculates that the highest permissible level of exposure, based on the Food Quality Protection Act's margin of safety for childhood risk, is 0.01 milligram per kilogram of body weight per day.

Figure 2. An excerpt of C's annotation of the *Mother Jones* article on glyphosate in food.

Furthermore, in her quote above, C also broaches the notion of the source of the artifact being an important consideration. When C brought up a similar sentiment in the focus group itself, none of the other folks in the group—Teta, Jayla, or Ash—had heard of *Mother Jones* before, and so they did not discuss the artifact source any further. Instead, all three expressed similar views to that of Alexa from above about the presence of pesticides in foods.

In the context of the first artifact, another source of prior experience that two students brought up was family members' experiences with related issues. Both Savannah and Ash referred to family members at least twice during the focus group. Savannah, in thinking about the first artifact, noted to the group:

I instantly thought about my grandmother again. She, uh, she rinses off her fruit with soap and water, or apple cider vinegar ... I would ask like, you know, why are you doing all this? And she's like, you know, they put these pesticides on them, and they linked back to cancer. And then, you know, when I read this and they're like, you know, it's possibly in our granola bars and oatmeal and all these other things. I just thought about last year where, um, I was a freshman and every morning, you know, I looked for a quick fix and it was like oatmeal every other morning or cereal ... How are we supposed to rinse that stuff off of cereal? I feel like that's just another way where they're trying to cover things up.

Layla, in building on Savannah's remark and alluding to an earlier theme from Pashiel concerning the working class, then added:

I don't know what rich people do, but I know that people in the working class, they always buy cereal, you know, and I would assume that, you know, if you, if you are a rich person, you have money to make an organic breakfast every morning, so you don't have to eat cereal. So, I kinda connected cereal to, like what tax bracket you're in and what you can afford in the grocery market.

When I followed up with Layla asking about this statement and her identity markers of Black, woman, and socialist, Layla noted that her identity as a socialist connected to that remark.

Students in the groups also drew upon their experiences strongly in discussing the third artifact (concerning race and crime). Prior personal experiences both with racism and with Fox News evoked strong reactions among the students in the focus

groups. I discuss this artifact next because of its similarity to the first in eliciting student reactions. Given that all the students disagreed with the argument of the article (both in their private written response and their public group response), students sought ways to speak back to the article, and prior experiences were among the first things students turned to. Five quotes representative of this theme are:

Savannah: I am an African American, and even if I wasn't, I would be able to tell this article is based on vague evidence ... I have witnessed four to five police officers tackling and killing a Black, and reportedly unarmed, male. Why, when you have tasers, guns, and professional training, did this man not see another day?

Jayla: This article is from Fox News, which has consistently proven to have a racist and right-wing bias. It overshadows the problem of police brutality as a whole by saying it is not the fault of White cops. Even if White cops don't have a "personal, irrational bias," racial targeting is something that's been institutionalized in American society.

Pashiel: Police have been killing Black people ever since the police force was created. There are plenty of books, movies, and witness testimonies to provide truth to that statement. Police have also been recorded killing Blacks and a majority of the time, they are not punished for it, so it would make sense that in 2018, with racism still existing in America, a police officer would not be afraid to kill a Black person on camera. There has also been an increase in the amount of "false alarm" calls that Whites have been making on Blacks to the police. There have been calls made to the police because the neighbors were too loud, a Black child was selling hot dogs outside, a family was cooking, etc., so I would like to know exactly what they consider in their data when they say that Blacks in areas of high crime are more likely to get killed.

Ash: In many of the recent police killings, the victims have been unarmed, innocent, queer, not of legal age. I think this article shows [a] stereotypical upper-class, White news outlet trying to sweep the issue under the rug and does not illuminate the actual horrors being carried out by poorly trained officers of the law.

Teta: This is not so true, I think. It makes me sad and really makes me uncomfortable that the news claims that White police do not unfairly target Black suspect.

Across these five quotes from students' written responses, we see evidence that students are employing prior experiences—whether related to eyewitness accounts (Savannah), knowledge from other media encounters (Pashiel and Ash), knowledge from other academic spaces (Jayla), or combined understandings from all of these (Teta)—to express their take on the artifact.⁵

As with the first artifact, it was also the case that family background influenced one student's written response. This time, though, it was Alexa, who was more reserved in discussing this artifact. In particular, Alexa noted that though she was Black, her uncle (who is also Black) was a police officer, and that the issue

⁵ Teta was somewhat less outspoken given that English is not her first language and she had only been living in the United States for two years. In a follow-up email with her, I asked her why she wrote what she did, and her response encompassed elements of the other three types of prior experiences I wrote about in that sentence.

(according to him) is more complex than the article made it seem. To that end, in her written response she noted:

Even if it is subconscious, racism is an ongoing issue and sometimes we unintentionally make assumptions or act a certain way because of it. I don't really know how to solve this debate between whether or not police officers are unfairly targeting Black suspects, and I don't know if body cameras are beneficial, but I respect police officers for the work that they do every day, assuming that they are all well-intentioned.

Later, I will return to Alexa's remark, as I was curious as to why she stated that she did not know if body cameras were beneficial. For now, the primary point to note from this quote is that she was drawing upon her experience with her uncle to understand the issue discussed in the article.

I discuss the second artifact (the *Vice News* clip on charter schools) last because it was somewhat less impactful on students in eliciting responses. In writing about and engaging in dialogue about this issue, students again drew on their prior experiences, but this time the overall lack of familiarity with the issue appeared to dampen students' contributions on the topic. As I broached the artifact to students after watching the video and had each student go around to give a brief overview of what they wrote, I asked students to also state for the group if they had ever attended a charter school; I also asked that they tell us if they felt confident about what the differences are between public, private, and charter schools. In going around one by one to share, two of the eight students (Savannah and C) stated that they felt confident about the differences between school types.

One (Savannah) of the eight students had actually attended a charter school. Subsequently, in responding to the group's prompt (concerning factors that are important for determining if a charter school is a viable option for one's child), Savannah drew from her experiences in a charter school to frame her written response:

I went to a Charter school from kindergarten all the way through 12th grade. I can be honest and say there was a good and bad ... The video made it as though charter schools think they're "better," but why wouldn't you want better? Not all charter schools cost to attend (mine did not), and not all charter schools ignore parent input (mine did not).

And while Savannah did mention these factors in her participation in the group conversation, she—following suit with other students who were less familiar with charter schools—was also quick to point out that she did not agree with what she perceived to be Betsy DeVos's platform on charter schools, and that she was saddened to see so many public schools in Detroit shutting down. Jayla, though not wholly familiar with the differences between school types, positioned herself as a Detroit native in her identity markers, which came through in her spoken response for the focus group:

Betsy DeVos probably has no idea how an education facility should perform for its students. A lot of the children in the video seemed to be White and obviously able to afford

the charter schooling. A large percentage of Detroit families are people of color and usually fall under the poverty line ... yet they're coerced into false "choices" to either send their children to an expensive charter school that isn't actually proven to be better or create another option for themselves once all of the nearby public schools close down.

Of the remaining six students not quoted with this artifact, five made similar (but seemingly less impassioned) negative comments about Betsy DeVos like Jayla. Teta, being unfamiliar with the US school context, expressed reservations about the utility of charter schools, and stated that she did not know enough information to provide a substantive response. In some ways, this response from Teta serves as a fitting transition to the other major theme concerning how the students in these focus groups discussed the three public issues: they expressed curiosity, asked questions, and interrogated the messages of the artifact's creators.

Asking Questions. Whereas with the first theme, the broad message was that students leveraged prior experiences, understandings, and other elements of their background to discuss the public issues, the broad message of the second theme is that students pushed conversations forward by asking questions and interrogating the artifact at hand. Here, the annotated articles and Google Form inputs were helpful for capturing students' responses, as they were more conducive to eliciting reflective reactions than in-the-moment verbal responses with the group. Indeed, recall that for each of the artifacts, I asked the students in the Google Form to answer the following prompt: "What's your general reaction to what you've just read or watched? Please include as much detail as you can—your response does not have to be polished or 'academic.'" It is telling, then, that across all eight students and 24 responses to that prompt, each student generated—without direction provocation—at least three questions as part of their reaction. With prompting (as part of the general process of annotation), students also asked several questions on their written annotation of the two articles.

With respect to the first artifact (concerning glyphosate), students' questions centered around three major points: the meaning of *carcinogenic*, the actual amount of glyphosate in their foods, and the discrepancy in the article between the Environmental Protection Agency (EPA) and the Environmental Working Group (EWG). Five of the eight students actually circled the phrase "probably carcinogenic" the first time that it appeared; two examples of this are provided in the annotations of Figure 3 below.

Note that, as the facilitator of the focus group, I avoided telling students the meaning of carcinogenic when it came up as part of the group share-out, and instead asked if anyone else in the group knew the meaning of the word. In both focus groups, students appeared to converge in agreement that a substance was either cancer-causing or not, and that the phrase "probably carcinogenic" was a ploy from the World Health Organization to avoid forcing companies to stop using glyphosate in their foods.

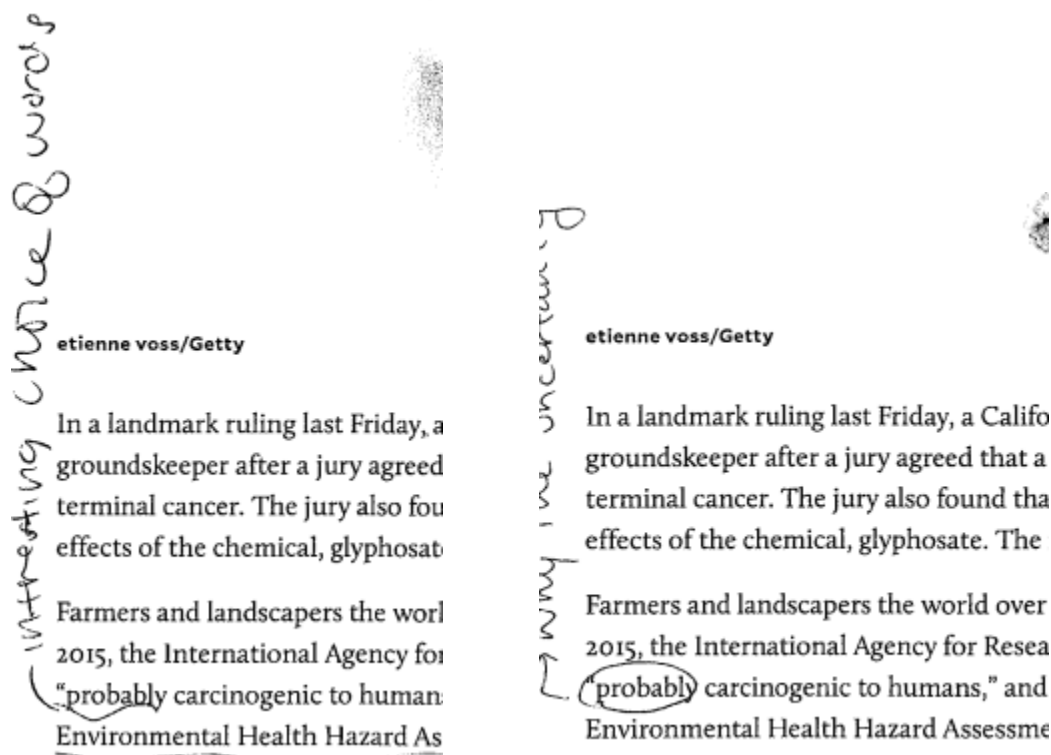


Figure 3. A portion of the annotations from Layla and Jayla of the beginning of the *Mother Jones* article. Here, both Layla (left) and Jayla (right) call attention to the phrase “probably carcinogenic.”

Beyond a concern about the phrasing of statements in the article, students were also concerned—once they assumed any amount of glyphosate was cancer-causing—that the EPA and EWG had differing recommendations for an allowable amount of glyphosate in food. For example, before the group share-out, Ash noted:

I think I’ll have to start rethinking what my foods are [and] where they come from for now on. If one group thinks that more than 0.01 milligrams per kilogram of body weight is too much, why should another group be so adamant on saying the human body can allow more than that?

Ash shared a similar view during the group discussion. During the group’s discussion, Teta’s concern was similar to that of Ash, as she stated:

I am a little bit surprised about all of it. If glyphosate was a cause of cancer to a grown-up man, what’s gonna happen to these kids who are eating cereals everyday of their lives? I think public health, and everybody should start looking into this seriously.

Just as with the first theme from above, students’ responses appear to be more impassioned (as evidenced in the number of questions asked) in relation to the third

artifact. Because students did not have substantial prior knowledge or experiences about the context associated with the second artifact (charter schools), their questions were more general (e.g., Why are schools closing down?). I do not include those here.

It was in the third artifact that students' questions were most interrogative (as evidenced in their framing as leading) and numerous. As with the *Mother Jones* article, some questions related to the sources or groups mentioned in the article. For example, C questioned what the Crime Prevention Research Bureau (CPRB) was, which had served as the leader of the study. C was the only one of the eight students who called attention to the CPRB in the written response or the focus group. Beyond her question about the source, most of the students' questions reflected a clear disagreement with the message of the article and came across as interrogative of the author and his stance. For example, Pashiel was curious about how the author could make a claim about the measurement of the construct of racism (Fig. 4).

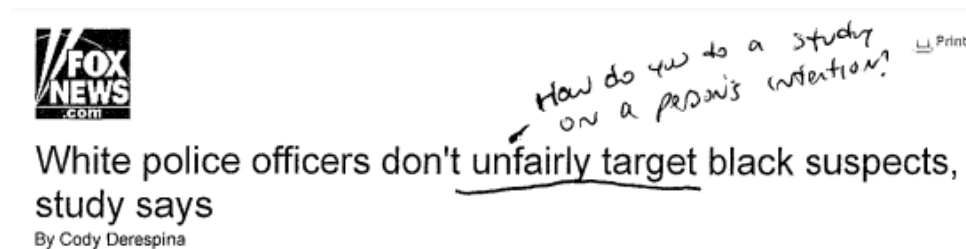


Figure 4. An excerpt of Pashiel's annotation of the *Fox News* article. Here, Pashiel questions how a study could tackle a construct that is dubious to measure.

During the focus group itself, Pashiel expanded on this concern, noting: "Like how do you know what they're telling you? What's actually true? Anybody can lie anyway, and of course you're going to lie if your job is on the line, of course you're going to say, oh no, it wasn't racially motivated." In a similar vein, Layla built upon Pashiel's remarks to question what was actually being studied. In particular, Layla noted that the study was only measuring police killings, not other metrics:

I'm going to say that this ... there's a lot of inconsistency with the article. I don't understand why the title says target and then we're talking about shooting ... There are different forms of targeting people. There's harassment, clearly, but there are other, there are many other ways to do that ... We're not mentioning whether they were armed or not, whether you know, what the threat of them actually was ... And um, about the fact they said, there being higher crime rates in black neighborhoods. They didn't say what the crimes in the neighborhoods were like. They can say what type of crimes are crimes, general crimes aren't threats to your life. Like, you know, like robbery and all that. We could be measuring this in so many ways. Is this study just to support Fox's agenda?

In her quote, Layla raises several points as she speaks back to the author of the article (and the study itself). While most of her comments are not questions per se,

they do raise questions and promote conversation, which is the nature of this theme in how students reasoned with public issues.

Taken together, across the two focus groups and the three artifacts, students leveraged their prior experiences and backgrounds to write about and discuss the three public issues; they also asked questions, often interrogating the artifact itself. Though not all that frequent, students also engaged in numeracy events, which I turn attention to in the next section.

Questions Two and Three: Numeracy Events and Their Characteristics

As described earlier, numeracy events are events mediated in some way by quantification (Craig and Guzmán 2018). In this study, such events are observable insofar as they are either written (in annotation or through the Google Form response) or spoken. In this section, I report findings related to the questions: Do numeracy events occur as students articulate their reactions? If so, what are the characteristics of these numeracy events?

The answer to the question, “Do numeracy events occur as they articulate their reactions?” is yes. In both focus groups and in relation to all three artifacts, numeracy events occurred. However, they were more commonly centered around students’ annotations of the two written artifacts than they were in the group discussion; furthermore, the importance of quantification or of numbers was more pronounced in the numeracy events when the quantification or numbers were central to the artifacts themselves (i.e., in this case, the *Mother Jones* and *Fox News* articles).

When and Where Numeracy Events Occurred. Both media articles contained quantities that students had the opportunity to make use of as part of their annotation, their Google Form response, or their reactions in the group share out. Such “latching on to” is characteristic of a numeracy event. An intriguing finding in this study was that these quantities manifest in students’ annotations more so than their Google Form response or verbal sharing. To expand on this finding, note that with the *Mother Jones* article, key quantities present in the article were the consumption recommendations for glyphosate in foods. These quantities included 2 milligrams of glyphosate per kilogram of body weight per day (the EPA’s recommendation), and 0.01 milligrams of glyphosate per kilogram of body weight per day (the EWG’s recommendation). All eight students in their written annotation of the article circled or commented on these quantities in some way. For example, whereas Savannah queried how much *she was eating* in her food (Fig. 5), Pashiel noted that we would not accept the same amount of “poop in our food” (Fig. 6); Layla, on the other hand, circled the two quantities and questioned why they were different (Fig. 7), as noted in the previous section.

products are safe, using an EPA's acceptable levels.

"Our products are safe and without question they meet regulatory safety levels. The EPA has researched this issue and has set rules that we follow as do farmers who grow crops including wheat and oats," wrote General Mills spokeswoman Kelsey Roemhildt in an email. "We continue to work closely with farmers, our suppliers and conservation organizations to minimize the use of pesticides on the crops and ingredients we use in our foods."

Figure 5. Snapshot of Savannah's annotation of the *Mother Jones* article. In this snapshot, we see that she asks how much glyphosate is present in the food she is eating.

how much am I eating.
 If there is 0.01 mg of poop in our food, we're not gonna want to eat it, but it's okay for pesticides to be in our food

Figure 6. Snapshot of Pashiel's annotation of the *Mother Jones* article. Pashiel wrote out (below the text, which is not included here) that while we allow 0.01 milligrams of glyphosate in our food, we would not accept a similar amount of a different substance (in this case, "poop").

A report released this morning by the Environmental Working Group (EWG) focused specifically on residue in food products containing oats. It found that many common breakfast cereals and snacks contain levels of glyphosate that it deems harmful, though the Environmental Protection Agency may not. so why's there conflicting views?
 The EPA, which considers Roundup "not likely to be carcinogenic to humans," deems an exposure rate of 2 milligrams per kilogram of body weight per day acceptable. EWG, however, calculates that the highest permissible level of exposure, based on the Food Quality Protection Act's margin of safety for childhood risk, is 0.01 milligram per kilogram of body weight per day. Very different again

Figure 7. Snapshot of Layla's annotation of the *Mother Jones* article. In this portion of Layla's annotation of the *Mother Jones* article, we see that Layla circled the quantities as important, noting they were "very different."

From Figures 5, 6, and 7, we see students participating in an individual numeracy event insofar as they are interfacing with quantities to engage on their own with the article. The other five students engaged in similar ways with the quantities. As students transitioned from the annotation phase to their typed responses concerning the article, only one of the eight students (Ash) brought up the actual quantities themselves; in that case, as quoted earlier, Ash had written: "If one group thinks that more than 0.01 milligrams per kilogram of body weight is too much, why should another group be so adamant on saying the human body can allow more than that?" Beyond this, though, across the two focus groups, the quantities themselves appeared only once in the group discussion (coming from Savannah).

When students shared their reactions to the article, Savannah noted: "... there's like a magic threshold. Oh well you can eat at least two milligrams per kilogram of body weight per day and they'll be fine. It's like, well no, I don't want to eat any." The rest of the discussion in this focus group centered on the presence or not of glyphosate in food, and all discussion in the other focus group (which included Ash) centered around the presence or not of glyphosate in food—not on the actual

amounts in the recommendation (e.g., how much food one would need to consume to surpass the recommendation, based on their own weight).

With the *Fox News* article, this pattern—that of latching on to quantities or quantification in annotation, but not in the typed response or group discussion—appeared again, though there were a few notable exceptions. In Figures 8 and 9, Alexa and Jayla demonstrate (as examples of the pattern across the eight students) that quantities or quantification were important for engaging with the article itself.

Among the findings of the investigation released Thursday by the Crime Prevention Research Center: White police officers are not significantly more likely to shoot black suspects; body cameras have had little effect on decreasing police killings; the more cops at the scene, the less likely it is a suspect will be shot.

POLICE SEE HIGHER THREAT OF AMBUSH AFTER YEAR OF UNREST

The study examined data from 2013 to 2015, a time period which almost perfectly bookends the police killing of Michael Brown in Ferguson, Mo., in August 2014, an episode that helped lead to the rise of the Black Lives Matter movement and placed increased scrutiny on police shootings. Yet, the research team of John Lott and Carlisle Moody found the percentage of black suspects killed in the 19 months before Brown's death (24.8 percent) was almost exactly the same as the percentage killed in the 16 months after Brown's death (25 percent).

Figure 8. Alexa's annotation of the *Fox News* article. Here in annotating the article, Alexa first circles the statement (a quantifying statement) that more cops at a scene were associated with a suspect being less likely to be shot. We then see below that she circled two critical percentages presented in the article.

The study examined data from 2013 to 2015, a time period which almost perfectly bookends the police killing of Michael Brown in Ferguson, Mo., in August 2014, an episode that helped lead to the rise of the Black Lives Matter movement and placed increased scrutiny on police shootings. Yet, the research team of John Lott and Carlisle Moody found the percentage of black suspects killed in the 19 months before Brown's death (24.8 percent) was almost exactly the same as the percentage killed in the 16 months after Brown's death (25 percent). *Just because the percentage hasn't changed doesn't mean it's not happening at all*

Figure 9. Jayla's annotation of the *Fox News* article. Jayla remarks that just because the percentages (24.8 and 25) are relatively similar, that similarity does not justify the conclusion the author makes in the article.

Note that the annotations from Alexa and Jayla are exemplars of those of five of the other six students. While these numeracy events occurred as individuals annotated, students primarily focused their typed responses and their group sharing on disputing the claim of the article in other ways that did not allude to quantities or quantification from the article itself (e.g., bringing up personal experiences with racism, discussing recent events from the news). The notable exception to this pattern was from Layla, whose group share out in relation to this article I quoted earlier. Layla focused specifically on the nature of what was measured in her annotated article, her typed response, and in the group sharing. Below is the typed response she provided after annotating the article:

... Committing a crime does not make you a high threat or that you're supposed to be shot. We need to look at other things such as injury of black people by police, harassment, shooting of unarmed black people and so forth. Not simply the number of those being shot. The mention of black police in the article, too, was also irrelevant. There was no follow

through; it was only briefly mentioned as they didn't supply any data of what black police officers were doing. There are also inconsistencies in this article that were not in the other ones. For example, they lead with the mention of saying race plays no factor in police shooting, only to say that black people commit more crime and that's why they're shot more.

In the quote above, Layla not only interrogates the claims that the author of the article made, but also provides other directions for one to consider if they were to aim to follow up on the conversation with further study. Layla gave similar remarks in the group share out (quoted earlier). Though Layla does not reference quantities specifically in her remark, she notes what quantities should be considered (i.e., what should be measured), and disputes quantitative statements (e.g., "black people commit more crime") that the author of the article made. In those respects, her typed response is an example of a numeracy event, as quantification mediated the way she approached the news artifact. Again, to summarize, across the discussions of the *Fox News* article in the two focus groups, Layla's comments constituted the sole numeracy event. This remark is not to suggest that students' discussions were not vibrant or engaged, but to highlight that they were mediated around other ways of talking about the issue. I discuss this finding in further detail in the next section.

I end this section by commenting on numeracy events surrounding the second news artifact (the video on charter schools from *Vice News*). Whereas with the two written media articles, quantities and quantification were arguably central to the authors' respective arguments, in the *Vice News* video, there were only two quantities mentioned: the number of charter schools opened in Detroit since 1995 (approximately 100), and the number of public schools closed in Detroit since 1995 (approximately 200). Students were instructed that since there was no article for them to annotate, they could write down comments about the video on a blank piece of paper as they watched. That being said, given the short length of the video and the fast-paced nature of the reporting, no students wrote down remarks on the piece of paper. Instead, they typed their responses in the Google Form, and shared them verbally during the group discussion.

With those two spaces for sharing in mind, note that there was only one numeracy event that occurred during either of the two focus groups. The numeracy event itself was from Layla's written response to the video, where she noted:

I liked that we were able to hear from both sides. The parent who felt forced to send her child to a charter school versus the man who worked for the school who argued that it was a choice and that they're being chosen by the people. It's interesting to see how the people who have the power choose to frame their words—how they speak about themselves. They say they're of the people. We heard two students speak but it makes me wonder what other children are saying, as well as how we can get more data on how beneficial charter schools are or are not. They said that test scores are the same, but isn't [there] something else we can measure such as child surveys? It's also important to consider that the children may feel a sense of superiority because of the freedom they have from their parents as well as what they're being taught by the higher-ups about the schools.

In this response to the open-ended prompt, Layla describes how one could take action—in this case, through collecting data—to learn more about the extent to which charter schools are beneficial. As with reactions to the *Fox News* article, the numeracy event here is again about the ways one measures a construct to analyze a situation. Note that when sharing out her remarks during the group discussion, Layla did not talk about these measurement questions; instead, in a manner similar to that of other students in the group, her comments were related to being confused about the nature of charter schools.

To summarize the results of this section, note that numeracy events did occur as students engaged with the public issues represented in the media artifacts. In both focus groups, students engaged with quantities pertinent to the artifact in their annotation more so than in their general typed response or their verbal sharing with the group. When numeracy events occurred in students' annotations, they were primarily to highlight that a specific quantity or statement was important in some way. Though the number of artifacts is too small to make any substantial claim, one should note that there were more numeracy events when quantities or quantification were central to the artifacts themselves (i.e., in the *Mother Jones* and *Fox News* articles). If a numeracy event encompassed more than highlighting as part of annotation, it was from Layla, who discussed measurement and how one might go about analyzing the issue in further detail. In the Discussion section below, I will comment on why this may have been the case, and what these results suggest about broaching public issues in postsecondary courses centered on numeracy.

Discussion

The research questions that guided this study centered around (1) *how* students in the focus groups discussed public issues, and (2) in relation *if*—and in what ways—numeracy events occurred as they engaged with those issues. The goal of (1) and (2) was to identify potential leverage points for discussing public issues with students in numeracy-focused courses. To that end, in this section, I discuss how the numeracy events from these focus groups might inform courses centered on quantitative literacy.

Numeracy Events

The numeracy events that occurred across these two focus groups demonstrate that students were attentive to the importance of quantities or quantification when exploring the two media artifacts where quantities or quantification were made apparent by the authors. However, as shown in students' Google Form responses and group discussions, the initial analyses that followed students' annotations were not centered around examining the issues from a quantitative lens; as noted earlier, the evidence and process necessary for calling these numeracy events numeracy

practices constitute open questions for the numeracy community. The one exception to this pattern was in the contributions of Layla, who consistently engaged with the issues from the perspective of measurement. Instead, most students' subsequent reactions were guided by students' interrogations of the artifacts through other lenses, such as personal experiences, family connections, and other aspects of students' identities. In responding to the *Fox News* article to the entire group, Alexa, for example, originally stated that she was not sure if body cameras were beneficial, using her personal experiences to justify her reasoning, rather than engaging directly with the arguments put forth by the author about why they were beneficial (per his argument). While there is nothing inherently wrong with the ways students chose to approach the three media artifacts, from a normative standpoint an educator would be remiss if they were to suggest that all of students' reactions are ideal. Instead, all reactions—whether ideal or “incorrect”—can be didactical for us as educators (Pardoe 2000). For example, it is apparent that students might benefit from learning more about the issues themselves (e.g., carcinogens, charter schools), or more abstract concepts related to the issues (e.g., measurement in education) to develop informed analyses of the artifacts. At the same time, we as educators can learn from students' existing ways of approaching such issues, benefitting in particular from the rich information that students' family experiences and prior backgrounds can inform ways that we approach such issues in the classroom.

Insofar as a central goal of coursework centered around numeracy is to understand and analyze real-world issues from a quantitative lens—simultaneously recognizing the importance and limitations of reasoning quantitatively (Steen et al. 2001)—these findings suggest that students will benefit from, and likely thrive in, coursework that allows them to build from their existing practices while engaging in learning about disciplinary norms for understanding real world issues through a quantitative lens. Though the construct of quantitative literacy is commonly said to defy any single discipline (Madison 2019), I use the phrase *disciplinary literacy* here because its meaning need not suggest that there is some platonic discipline one is becoming literate in, but rather, as noted by Moje (2015), that there are certain commonly accepted ways of approaching issues through the lens or tools of a specific discipline. In this sense, even if quantitative literacy is not tied to any specific discipline, one can still teach for quantitative literacy by exploring how both disciplines and broader modes of reasoning (e.g., scientific reasoning, historical reasoning) might approach issues from a quantitative lens. Engaging in this work is no trivial task for an educator.

With that in mind, Moje's (2015) 4Es framework for disciplinary literacy learning—engage, elicit/engineer, examine, and evaluate—may be of particular interest for those interested in drawing from students' existing knowledge and experiences (in the sense of what students leveraged in the focus groups in this

study) to engage in the analysis of public issues through a quantitative lens. According to Moje, the 4Es serve as a guiding heuristic for how one might go about doing so. To that end, note that the first E, *engage*, is to suggest that classroom practices should resemble those of experts in the discipline under study; in the context of a quantitative literacy classroom, that engagement might resemble the analysis process of a sociologist or a statistician, among other possibilities. The second E, *elicit/engineer*, is really two-pronged, and meant to convey the importance of eliciting students' existing knowledge and beliefs about a given topic (as discussed in Tunstall et al. 2018), and then engineering new knowledge based on what students bring to the table (while recognizing that education may not be able to overcome students' preexisting biases). For example, based on how students approached the *Fox News* article in this case, an educator could create a jigsaw activity in which students explored specific statistical concepts discussed in the article aligned with what students had found problematic when they first read it.

The third E, *examine*, reminds us to carefully consider with students the discourse practices of experts in a given field. Continuing with the *Fox News* example, a class could consider the challenges journalists face in presenting quantitative arguments to the general public. Finally, the fourth E, *evaluate*, similar to the third E, entails thinking through with students specifically how certain discursive practices and ways of approaching issues are potentially more valued within a given discipline. Within the *Fox News* example, this would likely mean discussing with students how anecdotal evidence has limitations for making arguments that are scrutinized by the general public. Furthermore, in the context of a quantitative literacy classroom, that might mean explicitly discussing the import of certain ways of approaching issues from a quantitative lens, and the inherent limitations of doing so. Ultimately, one hope might be for students to recognize the limitations of merely relying on anecdotal evidence (as some students did in these focus groups) to make public arguments (open to scrutiny) pertaining to public issues. A future direction for work in the study of quantitative literacy could be to document this process suggested by Moje in the context of a course centered on quantitative literacy.

Conclusion

The study contributes to existing literature on numeracy while raising new ideas and questions in the nascent context of practices related to numeracy at the postsecondary level. Though small in scope, there were two primary findings from this study: (1) students leveraged their background experiences and knowledge in articulating standpoints on public issues, and in relation, students actively expressed critiques and questions as they engaged with the three artifacts; and (2) numeracy events, when they did occur, were primarily centered around students'

acknowledgement of the importance of numbers, more so than actively referring to or using that importance through group conversation, or using such quantitative information to perform calculations or further analysis.

The first finding, which aligns with results in prior work (Tunstall et al. 2018) suggests promise for those teaching coursework in numeracy insofar as it demonstrates that students are likely to be engaged and excited to discuss public issues in postsecondary classrooms; this engagement should come as little surprise for readers. In the context of coursework centered around numeracy or quantitative literacy, this finding makes clear that it is critical to acknowledge students' existing beliefs and practices as they relate to discussing public issues; without doing so, one loses out on leveraging students' rich, existing ways of thinking about such issues, which, as evidenced in the way students discussed issues in the focus groups, they are likely to do in more realistic (i.e., out-of-class contexts) ways. One also might attend to the idea of motivated reasoning discussed earlier in this paper, given that students may use numeracy skills or other knowledge to arrive at conclusions aligned with preexisting beliefs. The findings also suggest that it is important to explicitly discuss background information about various contexts; though at first this recommendation may seem difficult for mathematics instructors who may not have the background knowledge themselves for understanding various public issues, it is nonetheless critical given that public issues are not solely about mathematics—there are a host of factors to consider. The work of those involved in (for example) teaching mathematics for social justice (e.g., Bartell 2013; Brantlinger 2013; Nasir and de Royston 2013), ethnomathematics (e.g., Meaney et al. 2013), or culturally-relevant pedagogy more generally (e.g., Morrison et al. 2008), can attest to this challenge and provide insights for those involved in teaching for quantitative literacy on how to approach common challenges that instructors face.

The second finding of this study indicates that there is both promise in, and a need for, structured means of exploring issues through a quantitative lens with students in classrooms centered on quantitative literacy. The numeracy events that occurred in the two focus groups of this study were primarily in students' annotations of articles, showing that students were aware of the potential importance of quantities or quantification as they went about completing the annotations. Nonetheless, because most of the students did not engage quantitatively with the artifacts in their typed responses or their group discussions, they may benefit from structured experiences with engaging with public issues from a quantitative lens. Of course, given that I did not broach the public issues in these focus groups with any explicit quantitative focus, it is unwarranted to say that students could not do so if prompted.

Future work building from this small-scale study could explore student numeracy events in further detail, whether by explicitly prompting students to

engage in using quantitative reasoning or taking a different approach and reporting on how students engage in the process of learning about the analysis of exploring issues through a quantitative lens. The framework given by Moje (2015) reported in the Discussion is one structured means of doing so with students. Finally, one might also work to better refine—theoretically, and then methodologically—what constitutes a numeracy event, and in relation, how numeracy practices follow from numeracy events. As noted throughout this article, identifying numeracy events was inherently challenging given its (understandably) broad definition. Expanding on the theory of numeracy events could allow us to, for example, better capture the avoidance of quantitative information despite its presence; one might also broaden what counts as quantification, including statements like “plenty of” or “an increase in the amount” found in this article as numeracy events. Though such changes would likely not overturn this study’s findings, they would provide more nuance, and importantly, more avenues for building on what students already do.

As noted at the outset of this study, a common rationale for having students enroll in general education mathematics courses is so they might learn mathematics or quantitative skills that they can draw on for use in their professional, day-to-day, or civic lives. This study suggests that there is research and curriculum development to be done so that students have a robust and engaged experience in completing such a course.

Acknowledgment

I am grateful for the assistance of Tonya Bartell, Lynn Fendler, Beth Herbel-Eisenmann, Vincent Melfi, Jeff Craig, and journal reviewers for their invaluable feedback in making this manuscript better.

References

- Agnello, Ellen C. 2021. “Simplified but Not the Same: Tracing Numeracy Events through Manually Simplified Newsela Articles.” *Numeracy* 14 (2): Article 1. <https://doi.org/10.5038/1936-4660.14.2.1375>
- Baker, Dave. 1996. “Children’s Formal and Informal School Numeracy Practice.” In *Challenging Ways of Knowing in English, Maths and Science*, edited Baker, Dave, John Clay, and Carol Fox, 80–8. London: Falmer Press.
- Bartell, Tonya Gau. 2013. “Learning to Teach Mathematics for Social Justice: Negotiating Social Justice and Mathematical Goals.” *Journal for Research in Mathematics Education* 44 (1): 129–63. <https://doi.org/10.5951/jresmetheduc.44.1.0129>
- Boersma, Stuart, and Dominic Klyve. 2013. “Measuring Habits of Mind: Toward a Prompt-less Instrument for Assessing Quantitative Literacy.” *Numeracy* 6 (1): Article 6. <https://doi.org/10.5038/1936-4660.6.1.6>

- Brantlinger, Andrew. 2013. "Between Politics and Equations: Teaching Critical Mathematics in a Remedial Secondary Classroom." *American Educational Research Journal* 50 (5): 1050–80.
<https://doi.org/10.3102/0002831213487195>
- Briggs, William. 2018. "Quantitative Literacy and Civic Virtue." *Numeracy* 11, Iss. 2: Article 7. <https://doi.org/10.5038/1936-4660.11.2.7>
- Carraher, Terezinha Nunes, David William Carraher, and Analúcia Dias Schliemann. 1985. "Mathematics in the Streets and in Schools." *British Journal of Developmental Psychology* 3 (1): 21–9.
<https://doi.org/10.1111/j.2044-835X.1985.tb00951.x>
- Craig, Jeffrey, and Lynette Guzmán. 2018. "Six Propositions of a Social Theory of Numeracy: Interpreting an Influential Theory of Literacy." *Numeracy* 11 (2): Article 1. <https://doi.org/10.5038/1936-4660.11.2.2>
- Derespina, Cody. 2016. "White Police Officers Don't Unfairly Target Black Suspects, Study Says." *Fox News*, November 16.
<https://www.foxnews.com/us/white-police-officers-dont-unfairly-target-black-suspects-study-says>.
- Erickson, Ander W. 2016. "Rethinking the Numerate Citizen: Quantitative Literacy and Public Issues." *Numeracy* 9 (2): Article 4.
<https://doi.org/10.5038/1936-4660.9.2.4>
- Hamman, Kira. 2017. "Rethinking the Numerate Citizen: Quantitative Literacy and Public Issues—Discussion." *Numeracy* 10 (2): Article 12.
<https://doi.org/10.5038/1936-4660.10.2.12>
- Kahan, Dan M., Ellen Peters, Erica C. Dawson, and Paul Slovic. 2017. "Motivated Numeracy and Enlightened Self-government." *Behavioural Public Policy* 1 (1): 54–86. <https://doi.org/10.1017/bpp.2016.2>
- Karaali, Gizem. 2020. "Quantitative Literacy: A Tool for Survival." *Numeracy* 13 (2): Article 5. <https://doi.org/10.5038/1936-4660.13.2.1370>
- Kunda, Ziva. 1990. "The Case for Motivated Political Reasoning." *Psychological Bulletin* 108(3): 480–98. <https://doi.org/10.1037/0033-2909.108.3.480>
- Liamputtong, Pranee. 2011. *Focus Group Methodology: Principle and Practice*. Great Britain: Sage Publications. <https://doi.org/10.4135/9781473957657>
- Madison, Bernard L. 2019. "Quantitative Literacy: An Orphan No Longer." In *Shifting Contexts, Stable Core: Advancing Quantitative Literacy in Higher Education*, edited by Tunstall, Samuel Luke, Gizem Karaali, and Victor Piercey, 37–46. Washington, DC: Mathematical Association of America.
- Madriz, Esther. 2003. "Focus Groups in Feminist Research." In *Collecting and Interpreting Qualitative Materials*, edited by Norman K. Denzin & Yvonna S. Lincoln, 363–388. Thousand Oaks, CA: Sage.
- Meaney, Tamsin, Tony Trinick, and Uenuku Fairhall. 2013. "One Size Does NOT Fit All: Achieving Equity in Māori Mathematics Classrooms." *Journal for*

- Research in Mathematics Education* 44 (1): 235–63.
<https://doi.org/10.5951/jresematheduc.44.1.0235>
- Mellow, Gail O. 2018. “Quantitative Literacy: Now More Than Ever.” *Numeracy* 11 (2): Article 1. <https://doi.org/10.5038/1936-4660.11.2.1>
- Moje, Elizabeth Birr. 2015. “Doing and Teaching Disciplinary Literacy with Adolescent Learners: A Social and Cultural Enterprise.” *Harvard Educational Review* 85 (2): 254–78. <https://doi.org/10.17763/0017-8055.85.2.254>
- Morrison, Kristan A., Holly H. Robbins, and Dana Gregory Rose. 2008. “Operationalizing Culturally Relevant Pedagogy: A Synthesis of Classroom-Based Research.” *Equity & Excellence in Education* 41 (4): 433–52. <https://doi.org/10.1080/10665680802400006>
- Murtaugh, Michael. 1985. “The Practice of Arithmetic by American Grocery Shoppers.” *Anthropology & Education Quarterly* 16 (3): 186–192. <https://doi.org/10.1525/aeq.1985.16.3.05x1484b>
- Nasir, Na’ilah Suad, and Maxine McKinney de Royston. 2013. “Power, Identity, and Mathematical Practices Outside and Inside School.” *Journal for Research in Mathematics Education* 44 (1): 264–87. <https://doi.org/10.5951/jresematheduc.44.1.0264>
- Nurse, Matthew S., and Will J. Grant. 2019. “I’ll See It When I Believe It: Motivated Numeracy in Perceptions of Climate Change Risk.” *Environmental Communication* 14 (2): 184–201. <https://doi.org/10.1080/17524032.2019.1618364>
- Pardoe, Simon. 2000. “Respect and the Pursuit of ‘Symmetry.’” In *Situated Literacies. Reading and Writing in Context*, edited by Barton, David, Mary Hamilton, and Roz Ivanič, 149–166. London: Routledge.
- Porter, Theodore. 1995. *Trust in Numbers*. Princeton, NJ: Princeton University Press.
- Shoots-Reinhard, Brittany, Raleigh Goodwin, Pär Bjälkebring, David M. Markowitz, Michael C. Silverstein, and Ellen Peters. 2021. “Ability-related Political Polarization in the COVID-19 Pandemic.” *Intelligence* 88: Article 101580. <https://doi.org/10.1016/j.intell.2021.101580>
- Sonde, Kari. 2018. “The Roundup Chemical Found Responsible for Cancer Might Also Be in Your Cereal.” *Mother Jones*, August 15. <https://www.motherjones.com/environment/2018/08/roundup-monsanto-glyphosate-cheerios-quaker-oats-cancer-1/>.
- Steen, Lynn A., ed., and National Council on Education and the Disciplines (NCED). 2001. *Mathematics and Democracy: The Case for Quantitative Literacy*. Princeton, NJ: NCED.
- Thelk, Amy D., and Emily R. Hoole. 2006. “What Are You Thinking? Postsecondary Student Think-alouds of Scientific and Quantitative Reasoning

Items.” *The Journal of General Education* 55 (1): 17–39.

<https://doi.org/10.2307/27798035>

Tunstall, Samuel L., Rebecca L. Matz, and Jeffrey C. Craig. 2018. “Quantitative Literacy Courses as a Space for Fusing Literacies.” *The Journal of General Education* 65 (3–4): 178–94. <https://doi.org/10.5325/jgeneeduc.65.3-4.178>

Tunstall, Samuel L., Vincent Melfi, Jeffrey C. Craig, Richard Edwards, Andrew Krause, Bronlyn Wassink, and Victor Piercey. 2016. “Quantitative Literacy at Michigan State University, 3: Designing General Education Mathematics Courses.” *Numeracy* 9 (2): Article 6. <https://doi.org/10.5038/1936-4660.9.2.6>

Appendix: Characteristics of Participants' Responses to the Three Artifacts

Table 2
Characteristics of Participants' Responses to the Three Artifacts

Group	Name	Artifact One	Artifact Two	Artifact Three
1	Pashiel	Suspicious of government Concerned about working class Asks questions out of concern for health	Concerned about charter schools	Adamantly against message of the article Questions author's argument Cognizant of systemic racism
1	Alexa	Against chemical products Asks questions out of concern for health	Proponent of public schools Questions use of charter schools by parents	Recognizes difficulty of police work due to family connection Cognizant of systemic racism
1	Layla	Unsure of why there is disagreement between groups mentioned in the article	Wonders if there is a better way to measure issues discussed in video	Offended by some of the authors' statements Questions how the author could make such an argument
1	Savannah	Suspicious of companies Unsure of some topics in the article Discussed family member's experiences	Attended charter schools previously Doesn't necessarily agree with the framing of the video given her past experiences	Acknowledges flaws in logic of author Acknowledges past experiences related to racism
2	Teta	Concerned about children and their development, both locally and in home country	Unsure of charter schools and how to view them given that they are not prevalent in her home country	Believes author is not making a logical argument Notes this does not align with previous experiences with racism
2	C	Suspicious of companies, Monsanto specifically, and of political agendas more broadly	Dislikes charter schools due to previous coursework and knowledge about them Notes concern about Betsy DeVos	Concerned about friends and specific groups that are consistently targeted in hate crimes Asks questions about nature of data
2	Jayla	Unsure of why there is disagreement between groups mentioned in the article	Concerned about Betsy DeVos Suspicious of outsiders influencing public education in Detroit	Adamantly against message of the article Questions author's argument Cognizant of systemic racism
2	Ash	Brings up family history of purchasing products related to Monsanto Asks questions about issues discussed in article	Notes family members went to charter schools Unsure of which is best given that he went to public schools	Against the author's logic, asking questions about how specific claims were made Notes racism is an obvious issue in the U.S.