Education for Whom? Word Problems as Carriers of Cultural Values

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Is the mathematics presented in textbooks, trade books and standardized tests neutral? Drawing from critical theory and feminist epistemologies, the purpose of this research is to examine mathematics curricular material through two questions: "What is valued?" and "Knowledge for whom?" Findings indicate that mathematics texts contain multiple examples of problems that reify hegemony, the exploitation of people and a marked disregard for the environment. This paper includes ways mathematics educators can reconceptualize mathematics texts as inextricably linked to cultural reproduction and furthermore, to use these insights to build ways that mathematics educators can disrupt the current narratives and replace them with more equitable, inclusive, sustainable, and critical perspectives.

Introduction

Is the mathematics presented in textbooks, trade books and standardized tests neutral? For many K-12 educators, the answer is obvious: Of course; it's just numbers, and mathematics texts (textbooks, curricular materials and standardized assessments) are totally objective. However, what this knee-jerk response may fail to consider is the rich complexity and contextualization that mathematics texts carry (Bright & Wong, 2009; Gutstein, 2006; Boaler, 2009; Moses & Cobb, 2001). Although it's entirely possible that the contexts presented in mathematics texts are purposefully selected to convey a particular frame, I posit that the field of mathematics educational materials is simply part of a more insidious, unproblematized facet of institutionalized hegemonic educational practices. Speaking to this possibility (if not probability), Greer and Mukhopadhyay (2012) state, "mathematics and mathematics education are implicated in various forms of interpersonal dominance and in ideological struggles" (p. 229).

With the exception of vanguard educators like Greer & Mukhopadhyay (2012), Gutstein (2006), Boaler (2009), and Ball, Gofney & Bass (2005), few researchers have focused on mathematics as a carrier or transmitter of hegemony. Framed around the questions, "What is valued?" and "Knowledge for whom?" the purpose of this research is to highlight the ways mathematics educators can conceptualize mathematics texts as inextricably linked to cultural reproduction (Bourdieu, 1986), and use these insights to build ways to disrupt the current narratives of inequity and the privileging of particularly narrow perspectives in mathematics education and replace them with more equitable, inclusive and critical perspectives (Freire, 1982).

The mathematics educators described in this research critically analyzed (Kubota, 2004) mathematics items –word problems—selected from their classroom mathematics materials. They practiced uncovering the ways mathematics education is decidedly not neutral, but is instead politically and socially situated within a particular agenda. Using these new perspectives to examine this corpus, the educators were surprised to unearth hundreds of hegemonic examples. They plan to use their new insights to actively disrupt the hegemonic narratives and, with their students, co-create counternarratives intended to empower the learners.

Theoretical Framework

Informed by critical theory, this work "recognizes power—that seeks in its analyses to plumb the archaeology of taken-for-granted perspectives to understand how unjust and oppressive social conditions came to be reified as historical "givens"" (Cannella & Lincoln, 2012, p. 105). This term, "givens," serves well in the context of this research, as the use of this term in mathematics traditionally means "known." By employing critical theory, the intent of this work is to scratch away at these givens—particularly the most insidious examples in the canon of mathematics education— and cast light into what may have been not only the intentions of the original authors in invoking these givens, but also in recognizing that the most insidious forms of hegemony are those that are so far below the surface they may be considered *unintentional* by the authors. Further, this work seeks to reframe these assumptions in ways that may be more emancipatory

for all K-12 mathematics students in the U.S.—not just those already enjoying various forms of privilege.

Building upon these ideas, this work also draws from feminist epistemology, in that the situated-ness of the knowledge of mathematics signals a masculinity that is often unnamed and unchallenged. Invoking Anzaldua's (2002) concept of the *nepantlera*, which she describes as those who "facilitate passage between worlds" and who engage in thinking that seeks to "question old ideas and beliefs, acquire new perspectives, change worldviews, and shift from one world to another" (p. 1), this work frames the work of participants as active and agentic, questioning and challenging.

Methods

In an effort to provide an agentic opportunity for educators to begin to conceptualize (and then re-formulate) mathematics texts through a critical lens, this research is decidedly qualitative, and draws from the lived experiences and perceptions of the participants. This research is centered in the collaborative work of 58 graduate students (teachers and future teachers) who agreed to participate in this exploration. The participants were enrolled in one of 3 sections of a graduate mathematics methods course for educators, which focused heavily on a critical implementation of pedagogical content knowledge in mathematics.

To this end, participants were invited to first participate in an interactive critical discourse analysis experience (described below), and then identify three "problematic" examples of word problems from their own mathematics materials and generate a written analysis of each. Participants were then invited to participate in focus-group discussions to both share their insights and deepen their own understandings by considering the findings and perspectives of other participants. Finally, participants will take their word problems to their students, and generate contexts and situations that maintain the mathematics content while focusing on more socially just situations. Grounded theory (Glaser & Strauss, 1967) was used to generate codes and themes.

To begin, the participants took part in a collaborative analysis of a mathematics text, a picture book titled, "The Dot and the Line:

A Romance in Lower Mathematics" (Juster, 1963). The text, featuring 3 non-human characters, is described as, "a supremely witty love story with a twist that reveals profound truths about relationships—both human and mathematical—sure to tickle lovers of all ages" (Amazon.com, 2012).

Using Burbles' (1986) work, "Tootle: A Parable of School and Destiny" as a model for deconstructing this superficially innocent-seeming children's book, the participants were asked to consider the following in relation to The Dot and the Line:

> Where the text implicitly assumes certain social circumstances that can be raised to question; where it colors certain conditions with an evaluative shade, or makes outright judgments about them; and where it distorts, misrepresents, or offers a partial, incomplete version of social events, it can be subject to criticism (Burbles, 1986, p. 240).

Working from this perspective, participants readily identified examples from the text of sexism, heterosexism and heteronormativity, racism, violence against women, linguicism, and white privilege. Building from this experience, participants were then asked to look at their own curricular materials, either in their teaching or student-teaching settings, and select 3 examples (of word problems) to scrutinize using some of the same critical stances. Drawing from what Burbles terms "ideology analysis" or "ideology critique," students were asked to engage in, "an attempt to hold a portrayal accountable to social reality" (p. 240). They were asked to consider the following questions as they crafted their critiques:

- What is valued in this problem? Who has power?
- What is not mentioned/ missing/ assumed in the problem?
- What prior knowledge (aside from mathematics) is assumed for this problem?
- Does this problem contain or promote "aspirational" cultural values?

After completion of the activity, participants engaged in focus group discussions to both provide commentary on the process and also to discuss insights gained during their analyses of their chosen problems. Information from these focus groups, along with the written analyses of textbook items, were included in this research. Finally,

participants shared these examples with their students and collaboratively generated more appropriate, socially just scenarios.

Findings

One of the most common themes that emerged in the examples participants identified in the mathematics examples was that of consumerism and acquisitiveness. Dozens of problems were identified that focused on purchasing items, with the stated goal often being to acquire the maximum quantity for minimum cost. The problems were usually rooted in the perspective of the consumer, serving to normalize and routinize the act of shopping, reinforcing the ideals of capitalism and framing the readers / students as buyers. Here's an example from *Saxon Math Course 2* (Hake, 2007):

> Sasha had $500.00. She purchased four shirts that cost a total of $134.00. If each shirt cost the same amount, what is the cost of one shirt?

Another example is found in an extended activity called "Hawaiian Dream Vacation," found in the blackline masters for *Bridges in Mathematics, 2* (Snider and Burk, 1999), which includes the following squares on a game board for second grade students:

> You call home: $8. You check into your condo: $155. You buy a camera: $35. Charter a plane back to Oahu: $78. You rent a beach umbrella for the day: $35.

Some of the other items commonly featured in "buying" problems included laptops, televisions, jackets, cars, bicycles, and occasionally mildly baffling, no-picture-included things like a problem about a "snowskate." "A boy asked me what it was, and I had to go Google it," explained one of the participants.

Related to this, participants also identified dozens of examples promoting middle- and upper-middle-class values as highlighted in consumative acts. These examples (typically with a stated focus on calculating area and/ or perimeter) centered on re-carpeting, re-tiling, or re-painting rooms, walls, or other surfaces. A typical 5th grade

problem, found in on the website for Everyday Mathematics, (The Center for Elementary Mathematics and Science Education, 2015), reads:

> Regina wants to cover one wall of her room with wallpaper. The wall is 9 feet high and 15 feet wide. There is a doorway in the wall that is 3 feet wide and 7 feet tall. How many square feet of wallpaper will she need to buy?
> Another example is found in *Glencoe Pre-Algebra* (Malloy, 2003):

> Ashley is going to retile a part of a wall in her shower… The area of the square section to be retiled is 36 square feet. If each square tiles covers an area of .25 square feet, how many …tiles will she need?

What participants found troubling about this was the ways in which "re-anything" implies a disdain for not only an environmentalist orientation, but also the idea that it is framed as normal to keep up with current fashion in home decor. Participants also took issue with what they interpreted as classist ideals, in that those who elect to re-work parts of their homes are typically homeowners and not renters, and have the disposable income to support decorative projects. One participant explained her thinking on this, stating, "These problems tell me that it's "normal" to be a homeowner, and…I am expected to be constantly striving to "improve" my space in ways that cost money."

The other most commonly identified themes that participants found included middle and upper middle class examples of leisure activities. Common examples include problems like this one from *Big Ideas Math* (Boswell & Larson, 2010):

> It costs $175 to rent a jet ski for 2 hours. It costs $300 to rent a jet ski for 4 hours. Write an equation that represents the cost y (in dollars) of renting a jet ski for x hours.

Here's another example from *Primary Mathematics Textbook: Standards Edition, 2b* (Cavendish, 2009):

> David's swimming lesson started at 9:10 a.m. and ended at 9:50 a.m. how long was the swimming lesson?

Perhaps most worrisome are the examples that emphasized getting "cheap labor" and calculating ways to pay "the help" as little as possible. Here's an example from a school-endorsed website, mathhelpforum.com (2009):

> An orange grower in California hires migrant workers to pick oranges during the season. He has 12 employees, and each can pick 400 oranges per hour. He has discovered that if he adds more workers, the production per worker decreases due to lack of supervision. When x new workers (above the 12) are hired, each worker picks $400 - 2x^2$ oranges per hour.

The layered status-orientations in this problem may be seen as insulting and painful, while also reinforcing damaging stereotypes, framing migrant workers as being in need of supervision to work effectively.

Upon scrutiny, it's relatively easy to identify problems that, without naming it, seem to hint at race or racialized ways of knowing and being. One common example is illustrated in problems that focus on meals, like this one from *Algebra 1* (Larson, 2010):

> You want to plan a nutritious breakfast. It should supply at least 500 calories or more. Be sure your choices would provide a reasonable breakfast.

Table 1

BREAKFAST FOOD	CALORIES
Plain bagel	195
Cereal, 1 cup	102
Apple Juice, 1 glass	123
Tomato Juice, 1 glass	41
Egg	75
Milk, 1 cup	150

First, the way the problem is worded indicates that breakfast consists of options, and that the reader has a choice in what to select for the meal. While this is true for some students, there are also many

students who receive free or reduced price meals at school, and have no choice in what they are served. Although this breakfast is typical of what might be eaten in some U.S. households, is it common for people to have 3 different drinks at the same meal? It was noted that few of the options seem to be whole foods (except perhaps the egg or maybe the cereal), with the emphasis being instead on processed foods.

Additionally, what's emphasized in this problem is not the nutritional content, but rather, the calories associated with each food. The instructions, using the words "nutritious" and "reasonable" seem to assume some collective, baseline agreements of what these terms might actually mean in practice.

Finally, the inclusion of milk (assumed to be cow's milk) on this list of options for a "nutritious" breakfast fails to recognize the fact that the majority of people on the planet (~60%) are lactose intolerant, and it is primarily white folks (people of European descent) who are able to digest cow's milk (Itan, Jones, Ingram, Swallow, & Thomas, 2010).

Although most participants described experiencing a series of epiphanies around issues of social justice education and the subtle ways hegemonic thinking can creep into mathematics problems, as the result of their participation in this project, a handful of participants (4) instead had a different reaction that ranged from indifference to strenuous defense of the entire canon of mathematics problems discussed. One wrote, "I am inherently skeptical of reading values, ``cultural aspirations", and power dynamics into everything. In particular, I think most math textbook problems are made with little or no thought, and with the attempt to make it "relevant to students"." Drawing heavily from the work of Lockhart's (2009) generalized critique of "word problems" in mathematics, this participant went on to state, "I think to have borderline paranoia about how we as teachers are somehow perpetuating an oppressive system by assigning word problems that may involve a male carpenter instead of a female one is fairly ridiculous." So although the majority of participants in the research gained new insights into how mathematics educational materials may perpetuate worldviews and norms that may be damaging, insulting or otherwise excluding to some students, a few participants found that engaging in this research reinforced further solidified their complicity with or perhaps indifference to hegemonic thinking.

The next steps in this project involved the participants taking their selected mathematics problems back to their K-12 students for the

purpose of re-working, re-framing, or re-conceptualizing their chosen problems into examples that will more accurately suit the beliefs and ideals that will best serve the students themselves. Gutstein (2007) advocates for this form of co-construction of new meanings with students, stating, "While we cannot always directly or immediately affect macro political and economic structures, although that is an essential part of creating a more just society, we do have agency ourselves" (p. 438).

Discussion

As the literature on the ways current mathematics discourses may serve hegemonic ideals is only newly emerging, this work is significant in that it identifies an engaging and accessible means for educators to deepen their critical perspectives and undertake agentic activities that work against hegemonic patterns of discourse in schools. By locating social justice work in the critical analysis and purposeful re-shaping of mathematics contexts, this work broadens the field of opportunity for creating a more democratic and critical liberatory pedagogy (Freire, 1982; Frankenstein, 2009). The initial findings from this research suggest that given a supportive and collaborative forum, educators may be equipped to challenge the oft-replayed examples used in mathematics education and craft new and more socially just substitutes.

In exploring how engaging in this activity changed the thinking and professional practices of participants, several themes emerged. Initially, many participants expressed a sense of disappointment or shame at never noticing the preponderance of "troubling" math problems before. Once beyond this initial wave of guilt, some participants expressed outrage aimed in two directions: first, outrage directed at their own teachers for never identifying or challenging the hegemonic examples in textbooks and problems, and second, outrage directed at the authors, editors and publishers of the materials. However, most participants recognized that understanding of hegemony and the insidiousness of cultural reproduction is not part of the common conversation in mathematics education— if anything, it's avoided. Pennycook (2006) explains, "Any model of relation between language and society will only be as good as one's understanding of society" (p. 117). For authors, editors and publishers who have never been asked

to consider their work through the lenses offered in this paper, the problems identified as classist, sexist, heterosexist, racist, xenophobic or consumerism-oriented seem only natural. So where do we go from here, if anywhere?

First, and perhaps most obviously, I believe that as educators, we should strongly consider broadening our lenses to consider how different kinds of frames (mathematics contexts) may be interpreted and experienced by our students. What seems normal or neutral to me may be foreign, uncomfortable or even offensive to my students. But of course, this raises the concern with meeting the needs of all learners—how might I possibly account for and incorporate the range of conflicting and possibly confusing perspectives shared by my students? At root, I posit that the solution to this is to know one's students, and to create a classroom climate wherein challenging the status quo is accepted, normalized and encouraged. Educators can create classroom climates wherein it's normal for students to make note of what sits uneasily, to call out what may be seen as classist or sexist or racist, to identify and respond to what feels oppressive or colonizing in some way— even if these thoughts and ideas aren't at the point they can be fully articulated and outlined. Perhaps we can craft classroom communities where it's all right and normal to say "I feel uneasy about this, and although I can't exactly say why, there's something about it that feels wrong or off." Setting this space, where the students are authentically agentic, may provide educators with insights into how they might re-shape the mathematics contexts we ask students to engage with. In other words, this iterative process may better equip teachers to select more appropriate problems in the first place.

I posit that from this centering of the student's lived experiences, this centering of student voices, careful listening may provide educators with rich educational opportunities to expand their understandings of the kinds of things students notice, the kinds of things students bristle at, and the kinds of things students identify as problematic. Thus, this situation may set up a scenario in which teaching is symbiotic, and in the purest Freirian (1973) sense, the students inform the teacher and the teacher responds in kind, making better selections for the students the following year. Also, by asking students to intentionally re-shape their own curricular materials, their level of engagement with the actual content (as the need for fidelity to actual mathematics objectives will remain) may in fact deepen

student understandings— for example, when recrafting a problem about calculating the perimeter of an irregularly shaped room, it will be important for the student to present another context that focuses on the same mathematical objective. This may serve to benefit the students even more deeply that by simply completing the assigned problems.

Additionally, with this kind of grass-roots focus on the contexts presented in mathematics, it's entirely possible that a class of students (or even individual students) may wish to reach out to textbook authors and curricular material publishers with specific feedback on the ways their examples and wordings may be unwelcome or unsettling for students. This may, in turn, help to reshape the overall quality of examples textbooks choose to include.

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