Middle Grades Teachers' Views of Connecting Mathematics to Real-world and Social Justice Contexts

Contributing Authors:

Frances Gaskill

Mathew Felton

Frances Gaskill, M.A.T., is a 6th grade math and science teacher at Coolville Elementary School in Coolville, OH. Email: fl195707@ohio.edu

Mathew Felton, Ph.D., is an associate professor in the Department of Teacher Education at Ohio University in Athens, OH. Email: felton@ohio.edu

There are frequent calls to make connections between mathematics and real-world contexts. A number of policy documents recommend that learning mathematics using real-world applications is important in schools. The National Council of Teachers of Mathematics' (NCTM's) *Principles and Standards* (2000), their *Principles to Actions* (2014) and the *Ohio Learning Standards for Mathematics* (Ohio Department of Education, 2017) all call for real-world connections in the mathematics curriculum. In particular, among the *Ohio Learning Standard's,* eight standards for mathematical practice (SMPs), emphasizes that "mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace." (Ohio Department of Education, 2017, p. 5).

The Association for Middle Level Education (AMLE) (formerly National Middle School Association) (NMSA, 2010) highlights the importance of taking an interdisciplinary approach to middle grades curriculum that integrates complex real-world issues. In particular, they argue that young adolescents should "become actively aware of the larger world, asking significant and relevant questions about that world and wrestling with big ideas and questions for which there may not be one right answer" (p. 11). AMLE also advocates for an integrative approach to the curriculum that "helps students make sense of their lives and the world around them" (p. 21).

Despite widespread calls for interdisciplinary and real-world approaches to mathematics curriculum, many teachers experience challenges in enacting real-world mathematics (Gainsburg, 2008, 2009). Therefore, in this study we sought to investigate the following research questions: *What are middle school teachers' views about integrating real-world applications, including social justice issues, into their mathematical teaching? In particular, how do they respond to three example real-world tasks?*

Literature Review

While making real-world connections to mathematics content is often framed as preparing students to apply the information they learn in school to their daily responsibilities and careers, a growing body of scholars also sees real-world connections as a potential avenue for exploring social and political issues. Some scholars emphasize building on students' *funds of knowledge*—students', their families', and their community's interests and expertise—in the mathematics classroom (Civil, 2007; Civil & Andrade, 2002; Civil & Kahn, 2001). For instance, in one case a classroom teacher developed a unit exploring perimeter and area based on some of her students' and their families' familiarity with gardening (Civil & Kahn, 2001).

Other scholars emphasize explicitly integrating social and political issues, often from a social justice perspective (Felton-Koestler, Simic-Muller, & Menéndez, 2017; Frankenstein, 2009; Gutstein, 2006; Koestler, 2012; Stocker, 2008; Turner, Varley Gutiérrez, Simic-Muller, & Díez-Palomar, 2009). Teaching mathematics for social justice involves engaging students in learning about social, political, and controversial issues through mathematics. Social justice educators argue that teaching mathematics for social justice allows students to use mathematical analysis to develop their beliefs about the world, to question things that are not fair, and to find ways to positively impact society.

Classroom Examples

There is a growing collection of K-12 mathematics lessons that explore social and political issues, such as the impact of mortgage rates (Gutstein, 2013), differences in world maps and the calculation of unemployment rates (Frankenstein, 1998), the body proportions of children's dolls (Mukhopadhyay, 1998), the concentration of community centers (Brantlinger, 2005), animal shelter needs (Vega, 2012), and the possibility of closing a local school (Varley Gutiérrez, 2009). The following two examples that follow were utilized in the study to model for

participating teachers and stimulate feedback, and include a lesson on fracking (Hendrickson, 2015) and a lesson on school overcrowding (Turner & Font Strawhun, 2007).

Lesson on Fracking

Hendrickson (2015) describes a project in which her seventh grade students investigated fracking, which she chose, in part, "because fracking was so close to home, the topic was ripe for a mathematical exploration" (p. 368). The project began with background information on the topic, followed by a brainstorming session in which the students generated questions about fracking, such as "how much waste is put underneath our water system with one well?" (p. 369). After discussing if and how each question could be analyzed mathematically, each student chose a question to explore. Students then investigated their questions, which often required modifying them based on the information they could find. Finally, the students presented their findings to the class and responded to questions from their peers. The project ended with students writing a reflection on what they learned about fracking and the role of math in understanding the world.

Lesson on School Overcrowding

Turner and Font Strawhun (2007) describe how Font Strawhun taught a project focused on school overcrowding in her sixth grade classroom in New York City. The project began with Ms. Font Strawhun asking the students about issues about their school and community that concerned them. Among the topics was a "space crisis" at the school (Turner & Font Strawhun, 2007, p. 458). With detailed planning, the teacher developed a five-week project to study and compare the size of the school and the population with the building's occupancy regulations and with another school that was on a different floor of the same building. Examples of the work include measuring the widths of hallways, calculating the areas of bathrooms and classrooms, and comparing the amount of area per person with local building codes. The students' collected, analyzed, and organized their evidence and they presented the issue to the school board. This

project positively affected many of the students' perceptions of mathematics—they "came to view mathematics as a tool that could help them investigate important personal and social issues, explore issues of equity and fairness, and argue and prove their point of view" (Turner & Font Strawhun, 2007, p. 461).

In both examples above and in other work researchers have found that connecting mathematics to social and political issues leads to greater student engagement, viewing mathematics as a tool for understanding their world, and a stronger sense of agency—the feeling that they can do mathematics and influence the world in personally meaningful ways (Gutstein, 2006, 2013; Hendrickson, 2015; Turner, 2012; Turner & Font Strawhun, 2007). In addition, although their work does not focus on social justice mathematics, Lesh and Harel (2003) highlight the value in connecting mathematics to real-world contexts through mathematical modeling. They engaged students from schools "that served predominantly minority and disadvantaged populations" (p. 163) in using mathematical modeling to solve problems in real world contexts. The researchers argued that, "our research has shown consistently that youngsters who are among the least advantaged often invent more powerful ideas than anybody has ever dared to try to teach them" (p. 175).

Challenges

Some teachers worry about presenting social justice issues into the classroom due to the disapproval other teachers, administrators, or parents may express (Gutstein & Peterson, 2013; Hendrickson, 2015). One mathematics teacher in Toronto launched a Social Justice Data Fair with fifth and sixth grade students at an all-girls school (Alexander & Munk, 2010). The teacher maintained close attention on the presentations to ensure the students were keeping a safe environment in which everyone could speak freely. She was delighted to hear professional conversations among classmates and thoughtful follow-up questions after the presenters finished.

Though the Data Fair has been successful since the first year she implemented it, some teachers were initially skeptical of this idea.

Some teachers choose to include fewer real-world connections in some classes compared to others for various reasons including their mathematical ability, little enhancement noticed in their learning, trouble finding examples to use in class, and even students' English language skills (Gainsburg, 2008, 2009). In a survey of middle school and high school teachers Gainsburg (2008) found that, "teachers mainly get their ideas for real-world connections from their heads, and many feel hindered by a lack of resources, ideas, or training for making connections" (p. 215). Of the teachers interviewed, most claimed to avoid textbook word problems since they include limited information and sometimes outdated data. Overall, most of the teachers did not use connections that required critical thinking. They were mainly just verbal explanations indicating real-world connections. When these teachers were asked why they include real-world connections in their classroom, the most common responses were motivation and to make mathematics concepts easier to understand.

Despite the difficulties many teachers face in integrating real-world contexts, there are also examples of teachers putting significant effort into making relevant, real-world connections. For example, one student teacher worked to include real-world contexts in her lessons that her high school students would be interested in learning about (Trexler, 2013). She collected data from surveys of the class and held a focus group with a subset of students to better understand which problems they felt were most relevant and most clearly communicated the important mathematical concepts. Ultimately, Trexler decided that she was trying too hard to have a perfect social justice lesson in which the mathematics was integrated throughout. Instead she felt the focus should be on using mathematics as a tool for understanding for highlighting important

aspects of the real world situation. She argues this will make mathematics more than just a subject in school for students.

Another challenge teachers face is that it takes significant time and effort to make meaningful lessons that give adequate attention to both mathematics and the real-world contexts. This tension can be exacerbated by expectations to engage in particular forms of mathematics outlined in standards or emphasized on state tests. The tension between focusing on the "mathematics" and the "real world" is seen repeatedly in work with practicing teachers (Bartell, 2013; Gregson, 2013; Raygoza, 2016) and mathematics teacher educators or researchers (Brantlinger, 2013; Felton, Simic-Muller, & Menéndez, 2012). This tension is often seen as a conflict between what Gutstein (2006) calls "classical" mathematics—the mathematics needed to be successful in school, which often emphasizes abstraction and decontextualized knowledge—and the aims of social justice education in which the real-world remains a central component of analysis. For this reason, some scholars have identified mathematical modeling—in which mathematics is used to analyze real-world contexts—as a fertile topic for integrating social justice into the mathematics curriculum (Barbosa, 2006; Cirillo, Bartell, & Wager, 2016; Hendrickson, 2015).

Methods

This paper is based on the first author's (Gaskill) master's research project. This project was completed as part of a one-year master's program that leads to licensure in middle childhood education. The second author (Felton-Koestler) was Gaskill's advisor and also taught the mathematics methods course she took in her fall semester. For this study Gaskill interviewed seven middle school mathematics teachers about their beliefs and practices regarding connecting mathematics to the real world and to social, political, and controversial issues.

Participants

Research participants were recommended by Gaskill's mentor teacher during her student teaching experience. Gaskill interviewed her mentor teacher and her cooperating teacher. She had not met the remaining participants prior to the interviews. All of the participants were current classroom teachers at the same rural school district in Southeast Ohio. Many had only taught in this district, but some had previously taught in surrounding suburbs and cities. The participants' experiences are summarized in Table 1.

Table 1

Teachers' Backgrounds

Teacher*	Years of experience	Grade(s) taught	Grade(s) most taught	Current grade(s)
Janet	19	K-8	3,4,7,8	3, 4
Stephanie	12	4, 7	7	7
Amber	9	K-2, 4, 5	4	4
Margret	9	4, 6	4	6
Ashlee	15	1, 4	4	4
Luigi	24	7	7	7
Leigh	17	2, 5	5	5

* All names are pseudonyms

Data Collection

The interviews were semi-structured. Figure 1 lists the interview questions (questions 7 and 8 had similar follow ups to question 6). Following initial questions focused on the teachers' current practices (questions 1-5), there were three brief examples of using mathematics to explore a social issue (questions 6-8). Two of these questions came from the research literature discussed above, specifically Hendrickson's fracking project (2015) (question 6) and Turner and Font Strawhun's investigation into school overcrowding (2007) (question 8). The third example

was adapted from an activity in Felton-Koestler's mathematics methods course (Felton-Koestler et al., 2017, pp. 45–47).

1. What does it mean to you to make connections between the real world and math when teaching?
2. Would you say your math teaching includes connections to real-world contexts?
3. What does it mean to you to make connections between social, political, or controversial issues and math when teaching?
4. Would you say your math teaching includes connections to social, political, or controversial issues?
5. OPTIONAL: Some people say it is important to bring current social or political issues into class discussions and/or lessons so students can better learn about the world around them. Exploring these types of issues in the math classroom can help students gain a clearer understanding of the issue at hand. What are your thoughts on this?
6. Example: A middle school math teacher was working in a community where fracking had become a major controversial issue, so the math teacher felt that the students should learn more about it. She wanted them to be able to form their own educated opinion on the issue. The teacher allowed the students to investigate their own research question. They created their own mathematical models to figure out the answers to questions they had and to interpret the research.
    a. What do you think about a project like this?
    b. Would you ever use something like this in your classroom? Why or why not?
    c. What do you see as the strengths and weaknesses of this task?
7. Example: The following is one of several story problems a group of students had to solve: Andy and Larissa both work as middle school teachers in a private school, but for every $850 Larissa makes, Andy makes $1,000. If Andy makes $1,100 in a week, how much does Larissa make in a week? Specific math had to be done in order to find the answers to these story problems. It was not until the end that the truth behind these numbers were revealed. The numbers represented the gender pay gap, they showed the students the true gaps that exist in different occupations between men and women.
8. Some people emphasize making connections to students' lives. A teacher in New York City created a class project based on her students' concern that the school was too overcrowded. The project involved students measuring the halls, classrooms, and other spaces in their school and finding the area of different shapes. They compared the size of the school to the number of students enrolled. With some research on school regulations, they were able to conclude that their school was in fact overcrowded. They even took their findings a step further and presented their concern to the school board and were able to use mathematics to back up their argument.
9. Do you have any other thoughts you want to share about real-world connections and/or social and political connections when teaching math?

Figure 1. Semi-structured interview question protocol

Data Analysis

Analysis of the data drew on the grounded theory approach (Charmaz, 2014). Grounded theory involves iteratively engaging in the following steps: (1) generating new codes by identifying themes in the data; (2) organizing themes into broader categories, identifying relationship between themes, and operationalizing definitions of themes and codes; and (3) revisiting the data with the new coding framework. This process was repeated until no changes to the coding framework emerged. For her master's project Gaskill coded the data directly from the audio table. She created a table that divided each interview into time segments representing a significant line of thought and summarized each segment. She used these tables to develop a coding framework.

For this paper Felton-Koestler transcribed the interviews and analyzed the results using MAXQDA™, a software program for qualitative analysis. His coding was informed by Gaskill's original work and by his familiarity with the literature, but new codes were also allowed to emerge from the data.

Limitations

Data collected in the interviews may have been different if we provided alternative classroom examples for the participants to analyze. The examples, provided in the appendix, were snippets of other teachers' lessons involving social, political, and controversial issues. The participants did not receive full details of the lessons or in-depth backgrounds of the students involved. We attempted to select examples that varied in terms of more structured or open-ended lessons and the types of social issues involved. Therefore, it is impossible to know how the particulars of the tasks influenced their reactions. This research is only based on data from seven teachers, so it is not meant to be a generalization for all teachers but instead to begin to develop a framework for understanding practicing teachers' beliefs and practices.

Results and Discussion

In this section we discuss how teacher participants described their practice, the advantages of the three example tasks shared, constraints they saw in attempting to implement real-world tasks, and the relevance of the tasks to their students.

Teachers' Practice

All seven of the teachers believed it was important to connect mathematics to the real world and did so in a variety of ways in their classrooms. The teachers gave examples of three different types of real-world connections they made when teaching. Six of the teachers gave examples of using *story problems* involving everyday situations, such as "We have three oranges and two kids, how much, how many oranges do you each get?" (Leigh). These examples are what Felton-Koestler calls "stepping stone" problems where the math is made accessible through a familiar or imaginable context (Felton-Koestler, 2016; Felton, 2014). Four of the teachers described *mentioning real-world applications* for the mathematics being taught. In one case this involved asking students, "where do you think you would use this in real life?" (Margaret), but in other cases it involved the teacher sharing examples:

> One boy, a few years ago, their dad owns a lawn service company and tree cutting service. And we talked about how the dad would have to go out and make estimations before he could actually provide the service. And how providing an estimation would be important to the people, whether or not they want to continue with that service or not. (Ashlee)

Finally, two of the teachers mentioned the same large *project* they do at their school:

> We have a huge, enormous project we do here. We've done it for 15 years. It's called our 7th grade reality day…. We give kids, 7th graders, a chance to play grown up. And so they end up with a monthly income and they have to balance their monthly budget. So

> they have to go around to stations in our gym and pay their monthly bills without over spending everything. So they have to take care of all of it. (Luigi)

In contrast, when initially asked about connecting mathematics to social, political, or controversial issues (interview questions 3 and 4) six of the teachers said they did not address these topics when teaching math (the seventh teacher interpreted the question differently than we intended and instead discussed the controversy surrounding the adoption of the *Common Core State Standards*). In addition, three of the teachers expressed uncertainty about what this might look like in practice or what was being asked.

These results mirror those in other studies. Most notably, Gainsburg (2008) found that secondary mathematics teachers described a range of ways in which they made real-world connections, but that "most are brief and many appear to require no action or thinking on the students' part" (p. 215). This would seem to largely mirror the relatively straightforward story problems and mentioning of connections used by a number of teachers in this study. While these forms of real-world connections can be valuable, especially carefully constructed story problems (Felton-Koestler, 2017), it is important to recognize the limitations of these types of connections. Vershaffel and colleagues have identified how opportunities to engage in *authentic* real-world problem solving is often lacking in the classroom, which leads to students learning to *ignore* their real-world understandings and knowledge in favor of the "word problem game" (Verschaffel, Greer, & De Corte, 2000; Verschaffel, Greer, Van Dooren, & Mukhopadhyay, 2009). In addition, the fact that none of the teachers had examples of how they made connections to social or political issues, and that three of them asked for clarification or examples, mirrors work done with prospective teachers (Felton & Koestler, 2015; Koestler, 2012). This illustrates that, for the most part, many practicing and prospective teachers are simply unfamiliar with what it would mean to connect mathematics to social and political issues.

Advantages of Real-World Tasks

The teachers identified several strengths of the example tasks shared. Five of the teachers highlighted how a task involved important mathematical content. For instance, in discussing the overcrowding example, Stephanie said "So I really, really like that project of how much math is involved with it and you know in capacity of classrooms and how many students should be in each classroom." Other positives the teachers identified included learning more about the real world, the interdisciplinary nature of the task, and how it can teach other important skills, such as problem solving, public speaking, and taking action.

Constraints on Integrating Real-World Topics and Projects

Testing. Five of the teachers brought up state testing, along with other constraints such as pacing guides, principal expectations, and addressing standards, as significant obstacles to making real-world connections, especially when it came to longer term projects. Leigh, for example, stated

> While I understand that they need that type of learning, unfortunately it is not assessed in April, and that's the piece that's being taken out of our education. And people say "well you can still do that; you can intertwine the standards into your extended lessons." Bologna, on paper that looks great, but here in say southeast Ohio and choose your demographic anywhere, I mean every demographic is gonna have a negative, an obstacle to using this kinda teaching. That's what good teachers do. I don't feel that I'm valued as a good teacher anymore, I am a test administrator.

Often, when presented with the examples tasks (interview questions 6-8), the teachers talked about teaching material like this at the end of the year once state testing was completed:

> I think that we kind of push those type of learning opportunities until after the test. Cause what skills are they, what standards are you hitting? But I think they're important. (Amber)

Age, background knowledge, and skills. Five of the teachers explicitly discussed the age appropriateness of the three example tasks. Interestingly, there were three different ways in which the teachers considered the age appropriateness of the tasks. One teacher, Ashlee, discussed the age appropriateness of the *mathematical content*, stating "I think again it would depend on age. Fourth grade couldn't do a problem like that just because of the ratios and not [certain] with the division and things like that". Four of the teachers questioned whether the topic would appropriate for particular ages, for example, Janet responded to the fracking example with "I'm not sure sixth grade, but I think, you know, at least high school can get, can handle getting more into those social issues than your younger kids."

Finally, two teachers questioned whether students of particular ages would have the non-mathematical skills needed to complete the example tasks. For instance, regarding the overcrowding example, Amber said, "I think if it were more towards middle or high school, the kids could do that independently…. Whereas, the younger kids, I don't think, could do that." Related to this last theme, four of the teachers saw the background knowledge and/or skills needed to complete the example tasks as a potential drawback. For instance, in response to the fracking example, Margaret said, "some of them don't know how to do research…. Not that I think that's a weakness in the sense of them learning, but that's taking away from the math part of it when I'm teaching other skills as well."

Discussion of constraints. These results are similar to past research that teachers often struggle with the constraints of the classroom (Bartell, 2013; Gregson, 2013) and that prospective teachers consider age to be a significant consideration in whether or not to address

potentially controversial issues (Simic-Muller, Fernandes, & Felton-Koestler, 2015). The view that the need to focus on background knowledge and skills may detract from "the mathematics" is consistent with the tensions other teachers and mathematics educators have experienced, but also points to a potential disconnect between the educational goals described in policy documents and the curricular pressures, especially in the form of state tests, that many teachers experience.

Relevance

Relevance to the students was another significant theme, which was brought up by six of the teachers as either a positive feature of one of the examples (five teachers), an area where an example was lacking (three teachers), or as a key feature that would depend on the students (one teacher). The teachers' perceptions of the relevance of the task varied by teacher, as summarized in Table 2. This variation is important to consider as it suggests that not all teachers will respond to (or anticipate their students responding to) tasks in the same way.

Table 2

Teachers' Views of Relevance of Tasks

	Fracking	Gender	Overcrowding
Leigh		-	
Luigi	-	+	
Margaret	+	-	+
Amber	+	+	
Ashlee		+	+
Stephanie			+
Janet			

+ task is relevant
- task is not relevant

Conclusion

If teachers are to engage in the kinds of integrative teaching advocated by AMLE (NMSA, 2010), in which teachers collaborate across disciplines, use academic content to understand their lives and the world, and have opportunities to make "meaningful decisions about their learning" (p. 21), they will need environments that foster this kind of teaching. One of the most significant constraints teachers discussed in this study was state testing. This, combined with teachers' concerns that addressing real-world background knowledge and the skills needed to engage in open-ended projects would take away from the mathematics, suggests that there is a disconnect between the educational goals called for in policy documents and the educational pressures most teachers experience in the classroom.

As a field we need to be better understand the relationship between rich, real-world based mathematics and student performance on traditional measures of academic success, such as current standardized tests. While a large body of research exists on the effectiveness of teaching mathematics in a problem-solving, student-centered way (e.g., Kilpatrick, Martin, & Schifter, 2003), this work has largely ignored the more in-depth real-world investigations discussed in this paper. Understanding this relationship could improve how we support teachers in enacting these practices and could inform the design of or relative importance given to standardized tests so as to ensure that the teachers are able to emphasize important skills. Moreover, teachers need opportunities to explore a broad range of examples of what it means to connect mathematics to social and political issues, so they can identify examples that they feel comfortable using in light of their mathematical goals and their students' age and background skills. Finally, policy makers must consider whether current measures of student performance, especially standardized tests, accurately reflect the broad range of skills we hope students will develop in school.

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