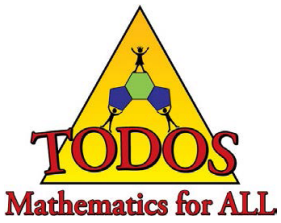

Supporting Prospective Teachers in Using Mathematics to Understand Our World

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Abstract

We, a teacher educator and two of my former students, discuss the role of *meaningful* real-world connections as a means to creating a more equitable and socially just mathematics curriculum. First, Felton-Koestler describes his use of real-world projects in courses for future teachers. Then Sutherland and Tracy describe their experiences with the projects and give examples of the real-world connections they made. Finally, we consider some of the themes across the prospective teachers' work and future directions for implementing this form of teaching in teacher education courses.

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Too often the mathematics curriculum is largely disconnected from real-world contexts and when connections are made they are often done in a superficial way with the context serving primarily as a "stepping stone" for engaging with mathematical concepts (Felton, 2014). As a result many students, especially those from traditionally underserved groups, do not see a connection between mathematics and their lives (Abreu & Cline, 2007; González, Andrade, Civil, & Moll, 2001; Howley et al., 2011; Mukhopadhyay, Powell, & Frankenstein, 2009). Moreover, students never learn about the role mathematics can play in understanding, questioning, and changing our world and in combating injustices (Frankenstein, 2009; Gutstein, 2006; Skovsmose, 1994; Turner, Varley Gutiérrez, Simic-Muller, & Díez-Palomar, 2009). Thus, one approach to creating a more equitable and socially just mathematics curriculum is to include authentic connections between mathematics and meaningful contexts that connect to students' out-of-school experiences or involve analyzing and critiquing social and political issues (Felton, 2014). The importance of connecting mathematics to the real world can also be found in the National Council of Teachers of Mathematics's (NCTM's) Problem Solving and Connections Standards (NCTM, 2000) and in the *Common Core State Standards of Mathematics* (CCSSM) (Common Core State Standards Initiative [CCSSI], 2010), especially in the standards for mathematical practice. However, many teachers have limited experiences with making substantive connections between mathematics and the real world and with social and political issues in particular.

In this article, we—Felton-Koestler, a mathematics teacher educator, and Sutherland and Tracy, Felton-Koestler's former students—discuss ways to connect mathematics to meaningful real-world contexts. First, Felton-Koestler discusses how he integrates real-world projects into his methods and content courses. Then, Sutherland and Tracy each describe how they used mathematics to investigate real-world topics in Felton-Koestler's mathematics course for prospective teachers, each of which is followed by an analysis by Felton-Koestler. Finally, we conclude by considering some of the themes that cut across Sutherland and Tracy's work and with suggestions for supporting prospective teachers in learning to integrate real-world contexts into their mathematics teaching.

Felton-Koestler: Social and Political Issues in My Courses

While there is great potential for using mathematics in meaningful ways in the classroom, in my experience and in the research findings, developing mathematics tasks that provide insight into the world is particularly challenging for prospective and practicing teachers (Bartell, 2013; Brantlinger, 2013; Felton & Koestler, 2015; Gregson, 2013). When teaching mathematics content or methods courses, I work to support prospective teachers (PTs) in learning to use mathematics to understand the world by having them complete projects in which they connect mathematics to a social or political issue of their choosing. While the PTs are encouraged to investigate a variety of perspectives on the social/political issue they select, I tell them that they will be required to consider the perspective of those with the least power in society. For instance, some PTs investigate obesity and they sometimes frame this as an issue of poor dietary choices, lack of exercise, and families who do not care enough about their child's well-being. In these cases I encourage them to consider the affordability of and access to healthy food.

In assigning these projects, I specifically emphasize that they are not required to be activities or lessons that would be used with children, so they feel free to choose a topic that interests them. One goal of the projects is for the PTs to experience for themselves what it means to connect mathematics to a real-world context that is meaningful to them. A second goal is that they begin to develop the ability to make these connections so that they are better able to do this when they become classroom teachers. In light

of the difficulties many teachers experience doing this work I see these projects as a first step in highlighting the potential for mathematics to help students understand social justice issues and their world. The projects are open ended; however, the PTs submit several drafts on which I provide extensive feedback. In the following sections, two of my former PTs share examples of projects they created in one of my courses.

Sutherland's Project: Teacher Pay around the World

Prior to Felton-Koestler's class, the mathematics I learned in school was never connected to the world that I lived in, so I learned to keep the two separate. This course showed me how big a role mathematics can play in my life and how I can show that to my future students. I have always been interested in teaching in other countries, so when we were assigned the project for this course I was interested in learning about teacher pay around the world.

When I began looking for data for my project, I started looking for data about yearly salaries for teachers in different nations around the world. Through research I found data from the Organization for Economic Co-operation and Development (OECD) (OECD, 2009a) and the Program for International Student Assessment (PISA) (OECD, 2009b) (see Figure 1 on following page for links). The OECD data revealed the biggest hurdle for my project. I had assumed that teachers around the globe worked approximately the same amount of time in a school year, but the OECD data showed that the average number of hours worked varied dramatically from country to country. I quickly realized that if I compared the average yearly salary for teachers, it would not be an accurate depiction of what teachers were really making for how much they worked. The data presented by the OECD showed information for dozens of countries around the world, which presented my second problem: Which countries would I use for my project? This is where the PISA data was useful. PISA studies student achievement on different tests every three years. I decided to take the countries with the ten highest scores from the PISA list (OECD, 2009b, p. 8) and compare them to the OECD data. I also included the United States, which was ranked seventeenth by PISA. Some of the countries in the top 10 on PISA did not have OECD data available for me to use, so they were cut from the project. Once I had all my data, I began to compute the hourly wage for teachers by taking the yearly salary of the teacher (which the OECD had already adjusted into equivalent U.S. dollars, thus controlling for differences in the cost of living), and dividing it by the average hours worked for teachers of that country. I did this for starting teachers, and for teachers with fifteen years of experience, since both pieces of data were available.

When I finished my calculations, I started writing problems that others could solve about the data I collected to compare the different countries' salaries. I created problems that could answer the questions that I had about the data I created. For example, one question I asked was "A new teacher in the Netherlands makes $36.85 an hour, and a 15-year teacher makes $47.75. What percent increase is this?" Other problems compared hourly starting salaries across countries or found the difference between teachers' average starting and 15-year salaries. This part of the project probably influenced me the most because I saw how I could teach children about social issues by having them do mathematics that relates to them and allowing them to research these issues on their own. One topic that I briefly explored with my own students was determining how many people purchase the video game Minecraft™ each week as a way of learning about multidigit multiplication. Students might extend a task like this by asking about how many purchase it in a year, which would require collecting additional data and/or making assumptions about times of the year that may have higher or lower sales. While this is not an overtly political issue, it was meaningful and relevant to my students.

This project proved to me how powerful it can be to answer your own questions about real world information using mathematics you learned in class. It takes mathematics out of the classroom and attaches it to something real. I experienced how much more meaningful mathematics was when it was directly connected to something that I was interested in.

When I begin teaching I want to teach mathematics so that it connects to who my students are and what

they want to learn. Students are not blank slates to be filled with knowledge by a teacher. They have ideas, hopes, dreams, and questions that can be answered with the information that they learn in school. I hope to be the person that shows them how to connect what they learn in class to the real world. I want them to know that they have the tools to answer all the world's questions, if they only have the desire to do so.

OECD Programme for International Student Assessment (PISA) (http://www.oecd.org/pisa/)

PISA 2009 Key Findings (http://www.oecd.org/pisa/pisaproducts/pisa2009keyfindings.htm)

What Students Know and Can Do, Executive Summary, Figure 1. Comparing Countries' and Economies' Performance (http://www.oecd.org/pisa/46643496.pdf)

Education at a Glance 2009: OECD Indicators (http://www.oecd.org/edu/eag2009)

- Indicator D3. How much are teachers paid?
- Indicator D4. How much time do teachers spend teaching?

Figure 1. Teacher pay resources.

Felton-Koestler's Analysis of Teacher Pay

I see two key strengths in Sutherland's work. First, Sutherland recognized that the quantity of *salary* from her data source was insufficient for making fair comparisons across countries because of the differing workloads. Therefore, she generated a new quantity of *(U.S. equivalent) dollars per hour*. In other words, she engaged in quantitative reasoning to generate a more productive quantity for making comparisons across countries (Thompson, 1994, 2011). Second, she was confronted with a large amount of data (salaries for dozens of countries)—which many PTs find to be overwhelming—so she developed a method of reducing these data down to a few countries of interest, which she decided to do on the basis of PISA scores.

There are also ways in which Sutherland could have more rigorously investigated her topic. For instance, she could have extended her examination of percentage increases in pay over 15 years of teaching to discuss how much each country appeared to value experience. With an eye towards issues of equity and justice, she could have also explored such questions as how teacher pay compares with other professions in the country, whether educators need additional income to earn a living wage, and what standard of living this salary makes possible.

Tracy's Project: School Lunches

At the beginning of our projects we had to brainstorm several possible ideas we might use for our projects. I ended up combining my early interest in analyzing funding levels for schools in Arizona with counting calories in school lunches. I noticed that federal funding has a huge impact on the food that the schools serve. Also, I had noticed increased attention to school lunches in elementary schools, and I wanted to research both further.

One of the main points of the project was to bring in the elementary mathematics. For most of Felton-Koestler's course, I was extremely skeptical that elementary mathematics could be used to understand these real-world issues. However, based on the class activities and readings, I was starting to change my mind, so I approached the project as an opportunity to prove to myself that I could make sense of these issues using the mathematics from our course.

The first part of my project focused on federal spending on school meals in Arizona. Figure 2 includes links to my data sources and some of the information available. Using this information I calculated the average spending *per year* and *per school day* if all Arizona students shared the spending equally (assuming an average of 180 days in a school year). I encourage the reader to consider what other questions could be asked with the data shown in Figure 2 and what additional information might be valuable to research.

The second part of my project focused on the nutritional content of school lunches. When I went to do my research, I found that there was a lack of publically available food menus from some of the schools. The ones that I found seemed to over emphasize the healthy foods being served. This was extremely frustrating, so I conducted my own research. I went to a local school that had advertised their healthy menu online and observed the food for myself.

I used the government site choosemyplate.gov to determine nutritional information from the data that I collected from the schools. I was shocked to find that the food actually being served frequently exceeded the recommended daily intake for things like calories and sodium. I was then able to create a variety of mathematics questions. For example, one question I created was: "it is recommended that a 14 year old eats 46 grams of protein each day. At school, Cameron (age 14) consumes 85 grams of protein. How many times the recommended daily allowance of protein did Cameron have at school?" This is a multiplicative comparison, number of groups unknown problem (CCSSI, 2010, p. 89). I wrote different types of mathematics questions commonly found in elementary school (see CCSSI, 2010, pp. 88–89) by looking at recommended nutritional amounts compared to how much they were getting at school, or by finding out how many calories or how much sodium is allotted to the children for the rest of the day.

I learned so much from this project. It gave me the opportunity to see my topic up close and hands on. I saw that the elementary mathematics that we teach our students can be used with real world contexts. Solving problems without any real world context may not be effective for many of my future students and would not allow me to engage in the authentic teaching that I plan to use. I believe that when teaching mathematics concepts to students we should not underestimate their ability to handle the context that goes with it.

This class definitely changed the way I am going to teach not only mathematics, but all subjects. In the beginning of the course I wrote that real world connections should initially be limited to basic, everyday topics that students "see or think about naturally" before getting into more complex and "'loaded' real life questions." At the end of the semester, I wrote that "in this class I have learned that the world and its views on different topics are constantly changing, and as a future teacher I need to be willing to change with it."

Federal Education Budget Project by New America Foundation.

- General: http://febp.newamerica.net/
- Arizona: http://febp.newamerica.net/k12/AZ
- 2011 Federal School Meal Funding in AZ: $296,544,150
- 2011 Total students in AZ: 1,071,751
- 2011 Percentage of AZ students enrolled for free or reduced lunch: 45.0%

ChooseMyPlate.gov (http://www.choosemyplate.gov)

Figure 2. School lunches resources.

Felton-Koestler's Analysis of School Lunches

I see two critical strengths in Tracy's project. First, many of the PTs in my courses struggle to find relevant and understandable data for exploring their topics. While not all PTs are in a position to collect their own data, I felt Tracy's (self-initiated) investigation into the food being served in a local school was an example of agency (Felton & Koestler, 2015; Turner, 2012). Second, she was shocked that school lunches (a single meal) often exceeded recommended *daily* allowances and she created problems that she felt illustrated these discrepancies. Thus, she created mathematics problems that, within the broader narrative of her project, were meaningful in that they illustrated the unhealthy nature of school lunches.

As with Sutherland's project, Tracy's work could also be strengthened by a more critical investigation of her topic. For instance she could have considered how much the extra calories/sodium/protein will affect someone's health, evidence of how it may affect rates of obesity or diabetes, and the economic impact of those health costs down the line.

Conclusion

Most of the PTs I (Felton-Koestler) work with have little to no experience making substantive connections between mathematics and real-world contexts (Felton & Koestler, 2015), and many practicing teachers and teacher educators struggle to make these connections in their own practice (Bartell, 2013; Brantlinger, 2013; Felton, Simic-Muller, & Menéndez, 2012; Gregson, 2013). Thus, I consider the work above to be a valuable first step in supporting PTs in making these connections in their

future practice. Both projects may be critiqued because they appear to use typical story problems with a slightly new context. While I agree with this concern, I also think it is lessened by the fact that these problems were part of a broader investigation (as opposed to stand alone word problems) in which they were meant to illustrate some of the concerns or findings the PTs had uncovered in their work.

While the level of social critique found in these projects is not what we would expect to see from a mathematics educator such as Gutstein (2006), who has extensive experience with, and is deeply committed to uncovering and investigating social injustices, it does represent an important step in coming to see mathematics as providing insight into our world. For PTs who entered my course feeling that "school was never connected to the world that I lived in" and that the use of mathematics should be limited to "everyday topics", the use of mathematics to examine inequities in teacher pay or the costs and quality of school lunches do, in fact, represent "controversial" or "political" topics that they are not used to seeing investigated with school mathematics.

Another common theme across Sutherland and Tracy's experiences was that they had an opportunity to experience what it means to connect mathematics to meaningful contexts. Both of these contexts were of personal interest to the PTs and they analyzed them in ways that furthered their understanding of the issues at hand. While their particular topics may or may not translate well into work with children, they both have embraced the idea that teachers should seek out ways to connect mathematics to their students' lives. As discussed above, this is one aspect to creating an equitable mathematics curriculum in that it positions students as problem solvers who are capable of using mathematics to understand problems both in their more immediate lives and in the world writ large.

In moving forward with this work with PTs, I am working to develop a collection of example projects that highlight some of the strengths discussed above, but that also include critical commentary, such as raising questions about how to more critically investigate one's topic. I intend to include discussion of these examples in my courses and then require PTs to bring in drafts of their projects for peer critique in which their peers can raise questions about other ways they might consider investigating their topics.

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