# Test Scores in the U.S.: Introducing the Data to Pre-service Teachers

**Mathew D. Felton**

## Abstract

I share a lesson in which I engage pre-service K-8 teachers in a mathematics content course in learning about the role of mathematics in understanding inequities in our society. Specifically, the lesson examines disparities in test scores in terms of race/ethnicity and eligibility for free/reduced lunch. I consider what messages this sends to and generates from pre-service teachers about the role of mathematics in understanding our world and I offer possible extensions of the lesson.

### Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. Why do we teach mathematics in school? In answering this question, how are you thinking about students (e.g., as future citizens, future workers, or future consumers)?
2. What do standardized test scores tell us about inequities in our educational system?
3. In what way can mathematics be used to raise awareness of and challenge inequities in our society?
4. What kinds of experiences do pre-service teachers need in their teacher education program if they are going to engage their students in these activities?

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What does equitable mathematics education look like? The equity principle in the *Principles and Standards* (National Council of Teachers of Mathematics [NCTM], 2000) states that "excellence in mathematics education requires equity—high expectations and strong support for all students" (p. 12). This is a view of equity as including *access* to high quality mathematics instruction (Gutiérrez, 2009). I wholeheartedly agree with the importance of this aspect of equity; however, this view does not question the mathematical content that students are expected to learn. Why do we teach mathematics in school, and more specifically, why do we teach the particular version of mathematics that is found in school? I view students as future citizens and as such I hope that they will leave the classroom with the ability to think deeply about the world around them, to understand the social and political issues facing our country and world, and to take action to address injustices created by our societal structures. I, and others (e.g., Gutiérrez, 2007, 2009; Gutstein, 2006), have argued that while access to high quality mathematics is absolutely necessary, equity must also include a re-envisioning of mathematical content to empower students to analyze and challenge structural forms of inequity in our society. For instance, Gutstein (2006) states that:

> Some argue that it is important that more students of color, women, and working-class students get access to mathematical courses and life trajectories. I definitely concur but argue against a presumption that more of these students in advanced mathematics classes and careers will necessarily change inequitable relations of power. I disagree with the position that urges increased access to mathematics opportunities, but that simultaneously leaves unchallenged the very structures that created the injustices. (p. 30)

In this article, I explore what it looks like to use mathematics as a tool for challenging existing injustices with pre-service K-8 teachers. I first describe the context in which I teach and a framework I use to inform my instruction and research. I then briefly describe and analyze a lesson I have used in my own teaching.

## My Teaching

I currently teach mathematics content courses for pre-service K-8 teachers (PSTs) at The University of Arizona in Tucson, AZ. The courses I teach focus on mathematics knowledge for teaching (Ball, Hill, & Bass, 2005) and are part of a required sequence that all K-8 PSTs take as part of an undergraduate teacher education program. The content courses are prerequisites for the mathematics methods course, and in my experience, the vast majority of the PSTs take the content courses prior to beginning the education program.

Through research focused on my previous teaching, I have developed a framework for examining the narratives we construct about what mathematics is and what it means to do mathematics. This framework is grounded in the views of the PSTs in my courses as well as prior research literature (see Felton, 2010a, 2010b). In my teaching and research I ask three questions regarding the narratives we construct about what mathematics is and what it means to do mathematics, which I refer to as the *What*, *How*, and *Who* of mathematics:

> *What* messages do we send about mathematics?
>
> *How* are mathematical concepts and real world contexts related in mathematics?
>
> Do people (the *Who*) experience mathematics more as a *mirror* reflecting back their experiences and concerns or as a *window* into a broader perspective? (The mirror/window metaphors are from Gutiérrez, 2007.)

I ask the PSTs in my courses to explore these ideas through a series of reflection assignments in which they write about mathematics, often in response to one or more readings. I

also use lessons in class that specifically highlight one or more aspects of the *What, How, Who* framework. In this article I focus primarily on what messages we send about the relationship between mathematics and the real world, and in particular the role of mathematics as a tool for social analysis (Spielman, 2009). I identify four levels of engaging in mathematics for social analysis (Felton, 2010a):

> *Real World Connections:* Using mathematics to understand everyday phenomena that are viewed or treated as neutral in nature.
> *Political Topics:* Using mathematics to understand topics that are viewed or treated as political in nature.
> *Awareness of Inequity:* Using mathematics to understand what the learner sees as systematic issues of inequity, particularly as related to race, gender, class, or other markers of difference.
> *Critique of Structural Inequity:* Using mathematics to critique the structural forces at work that produce social inequity by identifying structural causes and/or proposing alternatives.

Many of the PSTs enter my courses explicitly connecting mathematics to the real world. For instance, in a representative initial reflection one PST wrote:

> Math is needed for the success of a society and its economy. Math is used every day for this [sic] simplest of things. For instance, we count and make sure we have enough seats in the car for a group of people. We are constantly using math without even realizing it. Math is a basic need for functioning in society.

As illustrated in the above quotation, PSTs at the beginning of the course express real-life relevance of mathematics, but rarely make explicit connections between mathematics and political topics or issues of inequity. Thus, the PSTs enter my course largely echoing a traditional narrative of mathematics: that it is essentially neutral and disconnected from social and political issues facing our world. A number of authors have emphasized supporting learners of all ages in using mathematics to understand issues of inequity (see, for example, Frankenstein, 1997; Gutstein, 2006; Gutstein & Peterson, 2005). I extend this work to a mathematics content course for PSTs. One of my course goals is to challenge the PSTs' views of mathematics as neutral by highlighting ways that we can use mathematics to understand political topics, particularly issues of inequity in our society (levels 2-4 of social analysis). In the following section, I provide an example lesson I designed that highlights the role of mathematics as a tool for social analysis.

## The Lesson: Test Scores in the U.S.

Description of the Lesson

I have used this lesson as an introductory lesson in data analysis in a content course for prospective K-8 teachers; the course topics are geometry, measurement, data analysis, probability, and algebra. At this point in the class we have done relatively little work on comparing and analyzing data presented in graphs or tables. I begin the lesson by introducing the National Assessment of Educational Progress (NAEP), describing it as a low stakes test, and giving the fourth-grade benchmark scores for mathematics (*Basic*: 214 or higher; *Proficient:* 249 or higher; and *Advanced:* 282 or higher). I also discuss the "achievement gap" and emphasize that many researchers prefer to call this an "opportunities gap" because it is related to the educational opportunities available to students from different groups (Flores, 2007). I then explain that we will look at race/ethnicity—specifically, NAEP scores of White, Black, and Hispanic fourth graders—and I define how NAEP uses those terms. Finally, I explain that we will also consider students' socio-economic-status (SES) as measured by the imperfect, but widely available, data point of students' eligibility for free or reduced lunch. The national data in this lesson can be found at http://nces.ed.gov/nationsreportcard/naepdata/. The PSTs are asked to analyze the two bar graphs shown in Figure 1 and to respond to prompts such as:

(a) What do you see?
(b) Make comparisons between groups in each graph.
(c) What conclusions can you reach from these data?
(d) What additional information would you like? Why?

Following this, the lesson asks: "What data would help you figure out if race/ethnicity is a factor in the U.S. educational system above and beyond issues of SES?" The PSTs are then given the information shown in Figure 2 and are asked to respond to the four prompts above for these new data.

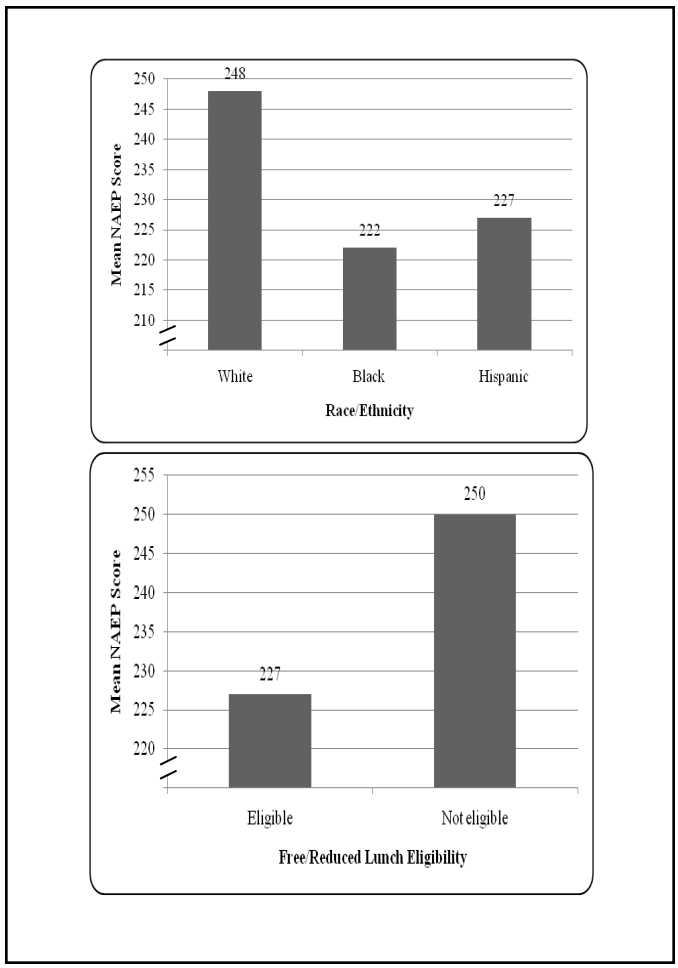


*Figure 1.* 2009 NAEP scores of fourth graders by race/ethnicity and lunch eligibility.

The PSTs then consider which graph is better for showing that race/ethnicity is a factor even after you account for different levels of SES and vice-versa. I use this last point to highlight that different representations of data are better for different purposes. I also mention that although we identified disparities in the bar graphs, this differs from the analysis a statistician would use to establish a statistically significant difference between groups. The PSTs are then asked to make similar graphs with the NAEP data for eighth grade students (available at http://nces.ed.gov/nationsreportcard/naepdata/). Finally, the PSTs are asked to discuss the questions shown in Figure 3, first in their groups and then as a whole class.

### Analysis of the Lesson

The National Council of Teachers of Mathematics (2000) calls for students in grades 3-5 to "compare different representations of the same data and evaluate how well each representation shows important aspects of the data.… [and to] propose and justify conclusions and predictions that are based on data." (p. 176). This lesson provides the PSTs with an opportunity to engage in these aspects of data analysis while simultaneously learning about an important form of inequity in our society.

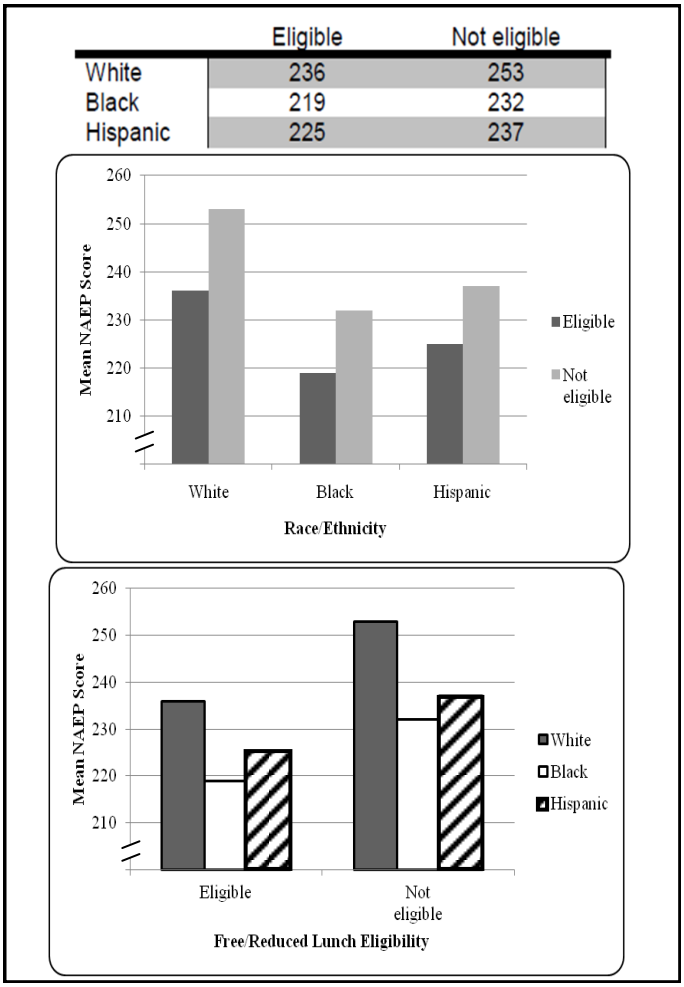


*Figure 2.* 2009 NAEP scores of fourth graders by race/ethnicity.

Regarding the *What* of mathematics, I intended for this lesson to send the message that mathematics is a valuable tool for understanding important real world issues. More specifically, this lesson serves as an example of how mathematics can be used to raise awareness about inequity in our society. Regarding the *How* of mathematics, the lesson highlights how real world contexts, such as test scores can be used as a meaningful context for learning mathematical concepts such as data analysis. Finally, with respect to the

*Who* of mathematics, this lesson may have functioned as a mirror because it connected to the PSTs' interest in and commitment to education and may have served as a window by deepening the PSTs' knowledge of this issue.

- What did you learn about educational outcomes in the U.S. today?
- Thinking about the *What*, *How*, *Who* framework from the Reflection Assignments:
- What level(s) of **What / social analysis** would you say this lesson focused on? Why?
  - Level 1: Real World Connections
  - Level 2: Political Topics
  - Level 3: Awareness of Inequity
  - Level 4: Critique of Structural Inequity
- Would you say that for **you** personally this lesson was more of a **mirror** or a **window**? Why?
- What was the relationship between the real world **context** of educational test scores, and the mathematical **concepts** (like analyzing data presented in tables and graphs)?
- What do you think about learning mathematics in this way?

*Figure 3.* Final reflection questions.

Examples of these three aspects of the lesson can be seen in the anonymous feedback I solicited regarding this lesson. In response to questions about this lesson and a lesson about income distributions in the U.S., the PSTs were asked whether they learned anything new about test scores or education in the U.S. and "how do you feel about *learning* (not teaching) mathematics in this way?" (emphasis in original). Out of 19 PSTs, 17 gave clearly positive responses, one indicated that "it was fine" learning mathematics in this way, and one wrote that while the visual aids in the lesson were good "the material is rather unsettling." PSTs' comments indicating further reflections or insights about testing in the U.S. included:

- "I didn't realize race had such an effect on test scores. I've always assumed it had more to do with economic status.… I like learning this way because it opens my eyes to actual facts instead of things I can't relate to."
- "I also learned that race (opportunity-wise) and SES has an affect [sic] on test scores.… I feel fine about learning mathematics in this way. I think it is very interesting and informative."
- "Yes, SES and race factors into test scores. Lower SES = lower test scores.… I enjoyed learning this way, it didn't feel like wasting time or just doing math, it was important."
- "Education: maybe because I already knew that there were differences, but I never knew how much it was.… I really enjoy it because it makes me aware about what's happening in the US."
- "It showed how much higher Whites test scores than Blacks + Hispanics, which is pretty sad.… I think it was interesting to learn this way and was easy to understand."

A consistent theme in the feedback is that using issues of inequity as a context made the mathematics more interesting and meaningful for the PSTs. An important area for further investigation would be the potential interplay of the race/ethnicity of PSTs with that of their students.

## A Potential Pitfall

A number of authors have pointed to the dangers of focusing on "achievement gaps" in mathematics education. For instance, Flores (2007) has pointed to the importance of reframing the "achievement gap" as an "opportunities gap," arguing that differences in test scores indicate unequal educational opportunities rather than inherent differences in racial/ethnic or socioeconomic groups. Flores argues that "blanket statements about the low performance of certain groups of students in our schools without mentioning the underlying causes may reinforce prejudices and stereotypical images" (p. 30).

Since the lesson described in this article does not examine underlying causes for the differences in test scores, PSTs may interpret the NAEP data in a way that reinforces negative stereotypes about racial/ethnic groups and poor students. Take, for instance, the quote from above, in which one of PSTs states "I didn't realize race had such an *effect* on test scores" (emphasis added). Does this indicate a belief that some races are inherently better at mathematics

than others or does this indicate recognition that opportunities to learn differ across racial/ethnic groups in the U.S.?

As discussed below, one way to address this concern is to expand this lesson to include investigation of inequities in the educational opportunities available to students. Due to time constraints this was not an option in my course. In lieu of this, I believe that two other aspects of my teaching discussed above help address this concern. First, in introducing the lesson I explicitly frame the lesson in terms of an "opportunities gap." Second, throughout the semester the PSTs reflect on the *What, How, Who* framework through a variety of readings about the teaching and learning of mathematics, some of which highlight the unequal educational opportunities available to students (e.g., Tate, 1994). Thus, although we were not in a position to examine the opportunities gap more directly, I did frame the issue in those terms.

**Possible Extensions**

As stated above, this lesson was used as an introduction to the data analysis portion of my course. Instructors of this course are expected to focus primarily on geometry and measurement, with some time devoted to data analysis, probability, and algebra. Therefore, while I also incorporate issues of equity into other portions of my class, there is relatively little time available in my course to expand on this lesson. However, this lesson could be extended to deal with more advanced forms of data analysis and to deepen PSTs' understanding of inequity of educational opportunities in the U.S. The NAEP website (http://nces.ed.gov/nationsreportcard/about/naeptools.asp) provides a wealth of statistical information and tools that allow the user to: (1) break down the data into other categories, such as state, English Language Learner status, gender, and student disability status; (2) run significance tests to make the analysis more rigorous (e.g., determining whether or not White students who are eligible for free/reduced lunch score statistically significantly higher than Hispanic students who are eligible for free/reduced lunch); (3) analyze changes in the scores over time; (4) create box-and-whisker plots of the distribution of student scores allowing for comparisons across student groups. Comparing box and whisker plots is found in the middle grades in both the NCTM Standards (NCTM, 2000) and the new Common Core State Standards (National Governors Association, 2010), and these comparisons can be valuable in highlighting the amount of *overlap* in NAEP scores that exists between different groups, which can counter the message that some groups are inherently better at mathematics than others. Another extension would be to explore what would happen if the benchmark scores for *basic*, *proficient*, and *advanced* were changed, thus highlighting the role of human judgment in interpreting standardized test results.

This work could also be extended by engaging the PSTs in a long term project in which they investigate the theoretical and empirical research, including the statistical data, on inequities in the educational opportunities afforded students in terms of race/ethnicity and SES in the U.S. Such analysis could include, but not be limited to, an analysis of school funding. Such an investigation would push this lesson from raising *awareness* of an existing inequity (level 3 of social analysis) to *critiquing* the inequity (level 4) by engaging the PSTs in understanding its origins and proposing possible alternatives.

Two notable examples of engaging teachers in an extended investigation of equity through a lens of data analysis can be seen in the McGraw & D'Ambrosio (2006) description of a workshop for teachers and Makar's (2004) analysis of a course for prospective secondary mathematics and science teachers. McGraw and D'Ambrosio describe a workshop designed to engage teachers in first analyzing several tables and graphs derived from the NAEP data and then using the NAEP data explorer (http://nces.ed.gov/nationsreportcard/naepdata/) to investigate state level data. Makar provides an example of a course focusing on assessment, instruction, equity, and inquiry for prospective secondary mathematics and science teachers. This course included a capstone three-week inquiry project into an issue of equity and fairness. Makar found that the prospective teachers deepened their understanding of statistics and in particular of their ability to connect statistical concepts to real-life situations. Interestingly, she also found that the depth of statistical analysis the teachers used correlated with their engagement in the topic they investigated, not with their level of statistical understanding, which points to

the importance of engaging prospective teachers in connecting mathematics to contexts that they find meaningful.

Finally, data analysis is not the only content area that can be used to analyze issues of inequity in our world. For instance, in the past I have had PSTs analyze poverty by creating hypothetical budgets based on the federal poverty line, which emphasizes the NCTM's (2000) Numbers and Operations strand. A variety of resources exist for using mathematics to analyze inequity. Lesser (2007) lists a number of possible topics for investigation in his Appendix 1 and list of Selected Website Resources. The website radicalmath.org includes a number of lesson topics organized by mathematical content and social justice issue. Finally, Gutstein and Peterson (2005) and Stocker (2008) provide sample lessons and reflections on teaching mathematics for social justice. These resources can be a valuable starting place for pre- and in-service teachers interested integrating issues of inequity into their teaching while simultaneously addressing mathematics standards.

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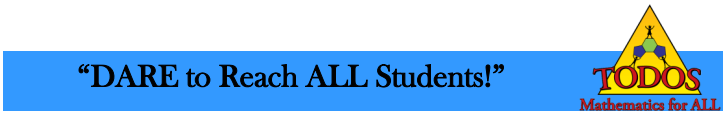
**Discussion And Reflection Enhancement (DARE) Post-Reading Questions**

1. What are some common messages sent to students (and teachers) about the nature of mathematics and its role in understanding and shaping their world? How are these messages sent?
2. What alternative messages can we send about what it means to do mathematics and how can we send them?
3. What other social and political issues would be of particular importance for future teachers to analyze mathematically?
4. What social and political issues would be of particular importance for K-5, 6-8, and 9-12 grade students to analyze mathematically?
5. How might you extend the *What, How, Who* approach to topics other than data analysis?
6. Is mathematics more of a mirror or a window for you? For your students?
7. Does the discussion of underlying causes of test score differences change how you think you will handle interpretation and discussion of test scores in the future? If so, how?

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