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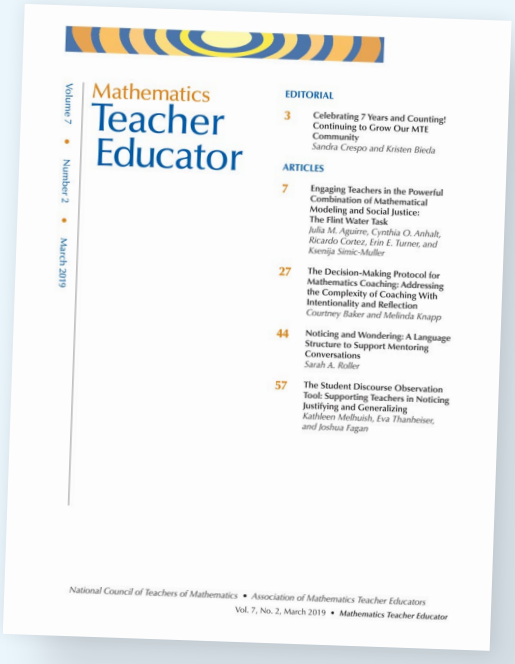

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Engaging Teachers in the Combination of Statistical Investigation and Social Justice: Fairness in School Funding

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This Perspectives on Practice manuscript focuses on an innovation associated with "Engaging Teachers in the Powerful Combination of Mathematical Modeling and Social Justice: The Flint Water Task" from Volume 7, Issue 2 of *MTE*. We built on Aguirre et al.'s (2019) integration of mathematical modeling and social justice issues in mathematics teacher education to similarly integrate statistical investigations with social justice issues.

Keywords: Data analysis and statistics; Equity; Curriculum; Mathematics Content courses; Mathematics teacher preparation

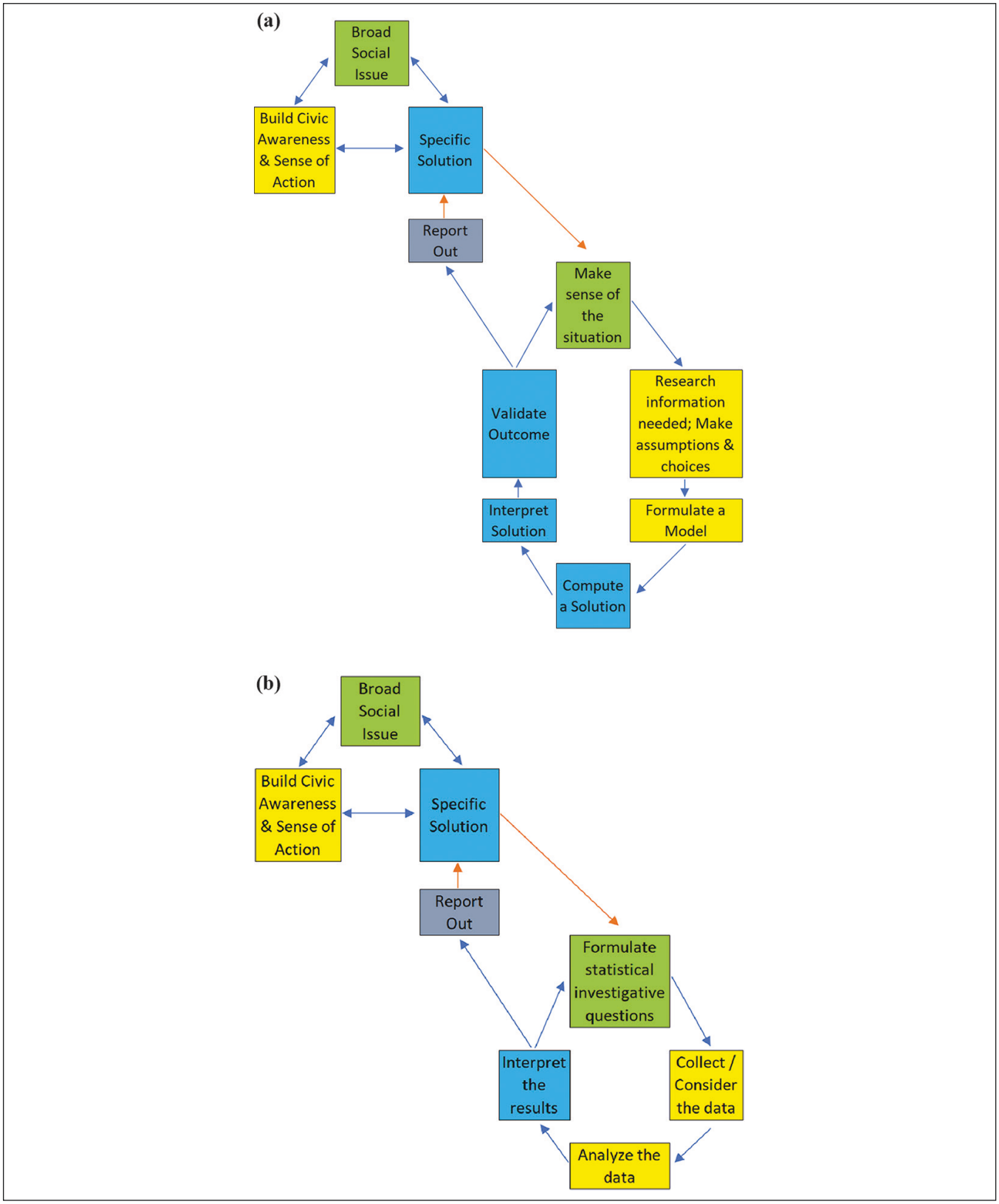
This article describes how we built on the work of Aguirre et al. (2019) regarding integrating mathematical modeling and social justice in teacher education to similarly combine statistical investigations with social justice in teacher education. Aguirre et al. (2019) developed a conceptual interaction between discussions of social justice and the mathematical modeling process, depicted in Figure 1a. The goal of this interaction was to create a model for designing teachers' learning experiences that strengthen their understanding of mathematical modeling and encourage using mathematics to scrutinize and critique fairness in social issues. In the teacher education materials (Casey et al., 2019) developed for the MODULE(S^2) project (available at www.modules2.com), we adapted this interaction to guide our design of statistical investigations that would support teachers in learning statistics and issues of social justice in a synergistic way. In our adaptation of Aguirre et al.'s work, we replaced the mathematical modeling cycle with the statistical investigation cycle (Bargagliotti et al., 2020) (see Figure 1b). The adaptation is needed for two reasons. The yellow phases of the statistical investigation cycle require focus on a dataset, whereas the analogous yellow phases in mathematical modeling could be data-centric but are not required to be. Regarding the blue phases, the idea of a "solution" being produced by the mathematical modeling cycle does not translate to the statistical investigation cycle, which never produces a definitive answer that one would call a "solution."

Aguirre et al. (2019) presented the Flint Water Task (FWT) as a learning opportunity they designed and implemented with teachers. The task employed their envisioned conceptual interaction (Figure 1a) around the social issue of access to clean water. Similarly, we present the Pennsylvania School Funding (PSF) activity as an application of our model (Figure 1b) to the broad social issue of fairness in school funding. The specific situation in the activity is the fairness of Pennsylvania's school funding, chosen because relevant data concerning school funding and contributing factors were publicly available and a grassroots effort pushed the government to examine the issue (Mosenkis, 2016). At the beginning of the activity, teachers learn about recent events regarding school funding in Pennsylvania, including the Pennsylvania legislature's formation of a commission tasked with determining a fair method to distribute state education funds among its school districts. The commission developed a fair funding formula that took into account multiple factors, including each district's median family income, number of students, and concentrated poverty. However, because implementing the fair funding formula would result in some districts seeing a large drop in state funds, the Pennsylvania state legislature decided to apply the fair funding formula to only 6% of the state's education funding, distributing the remaining 94% according to previous education funding practices. The teachers are then presented with a dataset (http://bit.ly/PennSchoolFunding) in the Common Online Data Analysis Platform (CODAP, 2014) containing demographic information about 499 Pennsylvania school districts, along with the actual amount of state funds they received per student and the amount of state funds they would have received per student if all of the state's funding was allocated with the fair funding formula.

Next, the teachers transition to engage in the statistical investigation cycle individually or in small groups through presentation of this statistical investigative question: Which demographic variable best predicts which school districts get less than their fair share? The teachers confirm that this question is a statistical investigative question because it is answerable with data and it anticipates variability. Moving into the next phase of

Figure 1

Conceptual Interactions Between Discussions of Social Justice and (a) Mathematical Modeling (Aguirre et al., 2019) (b) Statistical Investigation Cycle



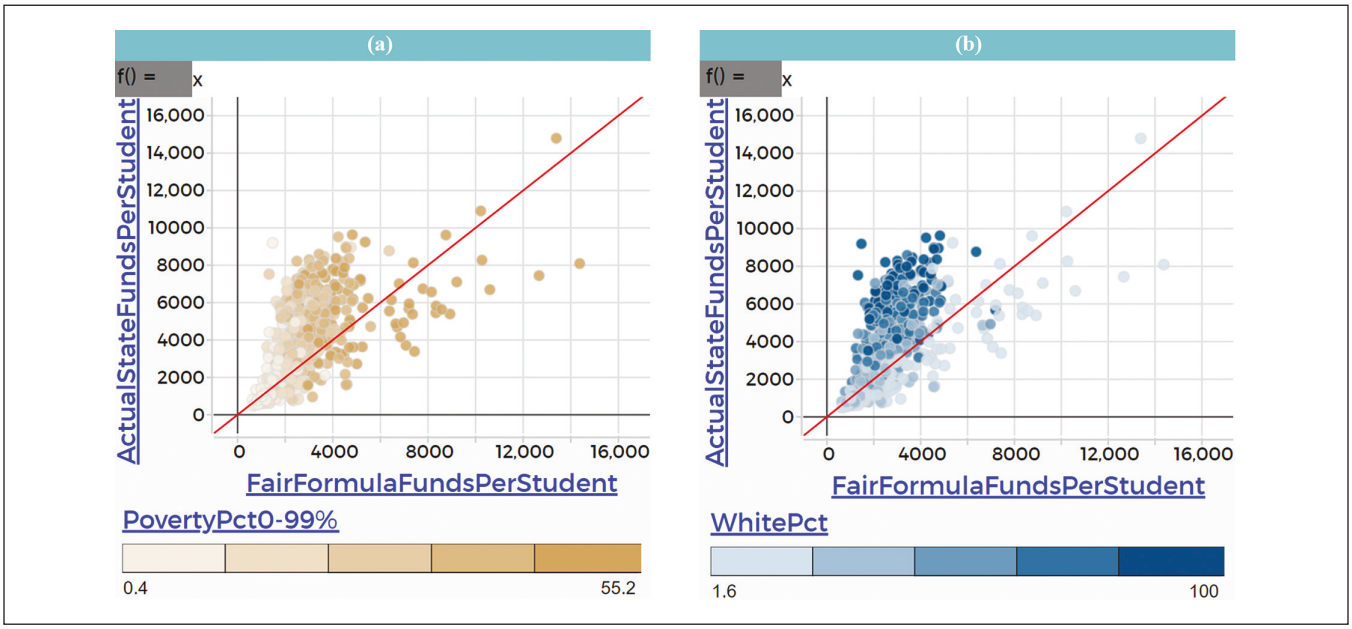
the statistical investigation cycle, teachers interrogate the precollected data to understand the meaning of each of the variables and develop ideas to inform their analysis. Next, teachers graphically analyze the data to answer the stated statistical investigative question. With some scaffolding from the activity prompts, teachers create graphs like those shown in Figure 2 to determine which demographic variable best predicts which school districts get less than their fair share. Interpreting the results of all the graphs they make, the teachers conclude that the variable regarding what percentage of students in the district identify as White (Figure 2b) is a strong predictor of which school districts will get less than their fair share. As shown in Figure 2b, lower WhitePct corresponds to getting less-than-fair-share funding on average.

A final prompt in the activity asks teachers to write a letter to a Pennsylvania state government official about school funding imbalances, creating a productive sense of action to enact change regarding a social issue based on a statistical investigation. Mathematics teacher educators implementing this activity debrief it with a whole-class discussion, working to develop teachers' understanding of how statistics can empower them to address social justice issues.

Aguirre et al. (2019) studied the implementation of the FWT with 19 in-service middle school mathematics teachers and found that the coupling of mathematical modeling and social justice learning deepened teachers' understanding of both. Similarly, we studied the implementation of the PSF activity with 26 preservice teachers at three universities in the United States. Analysis of the video recordings of the whole-class debriefing discussions in the class sessions where the PSF activity was enacted showed that the teachers' statistical investigations were robust. In every class, some teachers presented graphs like those in Figure 2 to analyze the data. Teachers also shared novel approaches to studying the data, like creating and analyzing a new variable that represents the difference between the actual and fair funding amounts per district. Teachers' interpretations of their analysis results demonstrated how their engagement in the statistics investigation fostered "critical analysis of a . . . current event that explicitly connects to humanitarian and social justice issues" (Aguirre et al., 2019, p. 17). For example, when interpreting graphs like those in Figure 2, teachers made statements like, "Most [school districts] are getting more than what would be fair because there are more points above the $y = x$ line than below it," and "The vast majority of schools that are getting more than their fair funding suggests are higher white percentage." These and other similar statements made by the teachers showed they learned important aspects about the social justice issue of school funding through their critical statistical analyses. Through writing a letter to the state legislature based on their work and the classroom discussions the mathematics teacher educators engaged in, the teachers were able to build on what they learned about the social

Figure 2

Graphs Made to Determine Whether (a) Percentage of Students Below Poverty or (b) Percentage of Students Who Identify as White Is a Good Predictor of Which School Districts Get Less Than Their Fair Share of State Funding



issue to take productive action concerning it. A synergistic connection that resulted from their learning about statistics together with social justice was the teachers' realization of the importance of using data-driven arguments in reporting about a social justice issue; as one teacher said, "[It is] best to include data, not just a written paragraph. If you include the data . . . , it makes it more powerful." The authors of the MODULE(S^2) curriculum and the mathematics teacher educators concluded the PSF activity provided a vehicle for teachers to learn about employing a statistical investigation cycle to meaningfully develop discussion of a social justice issue.

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