MODELING FOR SOCIAL JUSTICE: A MODEL-ELICITING ACTIVITY ON GERRYMANDERING

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Research suggests that for students to develop deep and connected mathematical understandings, they should solve real-world problems in which mathematics is used to model situations and construct solutions (e.g., Pollack, 1969; Lesh & Doerr, 2003). However, for teachers to effectively use mathematical modeling in their classroom, they must develop an understanding of the modeling process and learn to select, modify, and enact modeling tasks. To be prepared to enact modeling in their classrooms, pre-service secondary mathematics teachers (PSTs) need explicit support and education (e.g., Cai et al. 2016). Engaging PSTs in model-eliciting activities (MEAs, or tasks for which the creation and evaluation of a mathematical model is the primary goal) can help them both integrate and apply their mathematics knowledge and prepare to conduct such tasks as teachers (Daher & Shahbari, 2015). Meanwhile, attending to equity and social justice in pre-service mathematics teacher preparation is an urgent concern (e.g., Bartell, 2013; White et al., 2016). Although modeling and attending to equity may seem like disparate skills, the use of MEAs involving social justice contexts can engage pre-service teachers in studying and mathematizing situations to "experience mathematics as an analytical tool to make sense of, critique, and positively transform our world" (Aguirre et al., 2019, p. 8).

The issue of gerrymandering presents a good opportunity for integrating social justice into school mathematics, since it provides an example of authentic mathematics being used to influence public policy. Two actual U.S. Supreme Court cases in 2018 (most notably *Gill v. Whitford*) had significant mathematics content, with much of that math content accessible to K-12 students. Further, since teachers often cite a wish to avoid discussing controversial issues with their students (Simic-Muller, Fernandez, & Felton, 2015), a topic which is facially neutral (like gerrymandering) can be a useful entry point for novice teachers to incorporate social justice issues. All citizens can be concerned about whether or not their vote has an impact; this topic is particularly relevant for high school students who are preparing to vote for the first time.

Although the topic of gerrymandering can address a variety of mathematical topics (including proportions, statistics, etc.), our gerrymandering MEA focuses on the geometry of congressional districts. Many states require legislative districts to be "compact," but there is little agreement about how compactness should be measured. In fact, there are over 30 mathematical models of compactness used by political scientists (Kaufman, King, & Komisarchik, in press). With the goal of engaging PSTs in modeling for social justice, we created an MEA which asked participants to construct their own mathematical measure (i.e., model) of compactness and use their model to identify states which have the most gerrymandered districts. This model-eliciting activity draws on mathematical ideas appropriate for secondary mathematics classrooms, such as area and perimeter, scale, and attributes of shapes. In the activity, PSTs are given data including perimeter and area of congressional districts, as well as printed maps, and challenged to find a

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model which can rank districts by compactness. In a pilot implementation, PSTs struggled to conceptualize the geometric nature of compactness and downplayed its importance. They focused instead on issues of fairness in representation, including ideas of proportionality. This MEA thus provides PSTs with an opportunity to not only engage in rich mathematical practices, but also learn about relevant and pressing social justice issues.

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