AN EMERGING METHODOLOGY FOR THE STUDY OF PRESERVICE TEACHERS' LEARNING ABOUT EQUITY IN STEM EDUCATION

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A major challenge for elementary STEM teacher educators is incorporating social justice considerations across the span of professional program coursework. Recognizing that standards and policy documents are pressing for diversity and inclusion in STEM education, there is a growing need to support preservice teachers' learning about critical theories and how to develop an equitable vision of teaching. This paper describes ongoing research on our University's elementary STEM teacher education program. We focus our discussion on instrument development and the methods we used for eliciting preservice teachers' understandings of equity and diversity issues related to teaching STEM content. We designed a number of math, science, and technology scenarios in tandem, as means of building coherence across disciplinary boundaries; this report focuses on math teaching and learning.

Keywords: Qualitative Research Methods, Data Collection Instruments, Preservice Teacher Education, Equity and Diversity

Background & Goals: Building Coherence in STEM Learning Opportunities for PSTs

Commonly in teacher preparation programs, preservice teachers (PSTs) learn math and science content, technology in education, and teaching methods separately. Similarly, multi-cultural issues and the historical, sociopolitical foundations of schooling are also typically discussed separate from other topics and subject matter domains, if covered at all. There are known challenges with this lack of coherence and fragmentation in teacher education programs (Sirotnik, Goodlad, & Soder, 1990; Howey & Zimpher, 1989; Zeichner, Gore, & Houston, 1990). Broadly speaking, this fragmentation can lead PSTs to encounter contradictions or a lack of common language, and is overall an inefficient use of their time that can hinder PSTs in developing a clear vision of equity and the work of teaching.

Building on prior calls for coherent teacher education programs (Darling-Hammond & Bransford, 2005; Ritchie, An, Cone & Bullock, 2013), we are currently engaged in a long-term teacher education project aimed at building coherence in PST learning opportunities across disciplines and departments in undergraduate elementary teacher education STEM coursework. Our research team is comprised of math education experts, STEM content experts, and critical-theory scholars. Together, we have been working on a larger project and developing a vision of coherence based on theories of learning, cross-cutting concepts in math and science, as well as principles for fostering equity and social justice. In this paper, we focus on how we created, theorized, and piloted math tasks and in-class activities for the larger project.

Approach and Purpose of Study

Our research team has developed a class activity using a set of hypothetical teaching scenarios. These scenarios feature disciplinary content, student thinking, instructional design, and principles and dispositions around equity and social justice. These activities combine written tasks and prompts for group dialogue, through which PSTs engage in critical discussions that encompasses different aspects of classroom teaching and learning.

Using these tasks and in-class activity, we are collecting data in the form of PSTs' written work and transcripts of group discussions involving these teaching scenarios. With these data, we hope to survey teachers' prior knowledge, experiences, and assumptions pertaining to math content, student thinking, and, equity and social justice in math education. We seek to answer the following questions: What do PSTs already know? What are their productive resources and intuitions related to equitable teaching specifically in math? How do PSTs make sense of complex relational situations that they will likely encounter in future practice?

The Design and Rationale for Multi-Discourse Problematized Teaching Scenarios

During the Fall 2018, the research team designed and piloted instruments for eliciting and analyzing preservice teachers' knowledge related to equity and justice in math education. These instruments involve a number of specially designed tasks, each reflecting a *multi-discourse problematized teaching scenario* (MDPTS). Each MDPTS is a group activity for pre-service teachers and designed to elicit their perceptions and attitudes concerning a hypothetical, yet realistic, classroom scenario. MDPTS design was informed by previous research based on critical and sociocultural theories of math education (see below) and combines different elements highlighting various dimensions of classroom teaching such as content learning, social context, and power dynamics (cf. R. Gutiérrez, 2009).

The MDPTS were loosely inspired by existing work on scenario or case-based assessments in teacher education (e.g., see Shaughnessy & Boerst, 2018; Selling et al., 2015). Each MDPTS was designed to elicit different types of discourses, from about content, to classroom practice, to equity-based dialogue. Where applicable, MDPTS were designed to align with relevant math and science standards for elementary grades. Furthermore, some MDPTS were inspired by scholarship focused on equity, gender, and race in math education (e.g., R. Gutiérrez, 2009; Leyva, 2017; Martin, 2009).

MDPTS Example: "Mathematical Equivalence"

The mathematical equivalence problem presented in this scenario (Figure 1) is intended to build on student prior knowledge, and it creatively combines (and goes beyond) two core standards from earlier grades, namely, CCSS-M Standards 1.OA.6 and 1.OA.7 (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). This scenario aims to highlight the intersection of mathematical content, cognition, and gendered dynamics as a means of examining PSTs' knowledge within and across these areas.

Specific elements of "Mathematical Equivalence" were designed by adapting transcripts of utterances and emulating the tone of social interaction and mathematical behavior of students appearing in existing empirical work (Gutiérrez, Brown, Alibali, 2018; Heyd-Metzuyanim & Sfard, 2012). Specifically, it was designed to foreground mathematical content and cognition on the one hand, and gendered dynamics on the other. The psychology literature involving equivalence problems indicates the importance of noticing the location of the equal sign on individual strategy use and learning outcomes (e.g., Alibali, Crooks & McNeil, 2018). The hypothetical student ("Pat") wants to point out the (accurate) location of the equal sign, which is

the crux of the reasoning exhibited by the students in the scenario. The prompting strategy we chose for this scenario is intentionally open-ended for the PSTs to interpret the mathematical as well as the social factors that shape the interaction. Pat is not gender-identified, thus we hypothesize that the PSTs' interpretations of this scenario will vary according to whether/how they assign a gender to Pat.

Mathematical Equivalence

A class of 3rd graders is in the middle of an explorative unit on the equal sign that incorporates the following goals:

- Accurately notice the location of the equal sign in equations involving addition and subtraction
- Generate and compare different strategies for determining the unknown number that makes an equation true

A group of three students are working on solving the following equivalence problem:

8 + 5 + 4 = 4 + ___

A teacher overhears the following conversation:

Rebecca:	I'm not sure what to do. I'm confused. Do I fill in the blank?
Pat:	This is so easy guys! The answer is just 13.
Rebecca:	I don't think it's easy. That was rude Pat.
Gabe:	Plus, I don't think you did it right Pat. I think the answer is 17. 'Cause 8 plus 5 plus 4 is 17.
Rebecca:	Yeah. That seems smart.
Pat:	You guys are so dumb. You have to pay attention to the equal sign...
Gabe:	Don't act like the boss of us. You always act bossy.
Rebecca:	I think it's 21. Cause I added it all up.
Pat:	If you guys would just listen I could teach you how to do it.
Gabe:	We can figure it out ourselves. Thanks anyway.

Imagine you are an observer in the classroom. Please discuss the following questions:

1) What is the dynamic between the three students?

2) How do you think the dynamic came about?

3) If you were the teacher, when would you intervene? How? What would you do?

Figure 1: MDPTS–"Mathematical Equivalence."

There are subtle elements that were designed into this scenario which might allude to either stereotypical female or male gender roles in mathematics, which adds further complexity to our

analysis of the PSTs' perceptions of gender and math. At first read, one might assume Pat is a boy given the ways "he" asserts himself in the beginning and finds the solution procedure "easy." Yet, whereas these aspects of Pat's behaviors are aligned with dominant narratives of a masculine mathematician (Hottinger, 2016), Pat's behaviors also exhibit a feminine quality that resist this stereotype. Through it all, Pat wants to teach Rebecca and Gabe, and *teaching* mathematics is not typically associated with the historically gendered role of the masculine mathematician (cf. Hottinger, 2016). Another element in the scenario that could elicit PSTs' perceptions of not only gender and math, but also race, is the fact that it refers to Pat as "bossy." The term bossy can be perceived as a gendered as well as racialized term in math contexts (Langer-Osuna, 2011; McGee & Bentley, 2017), and these troubling narratives should be better understood in teacher education.

Preliminary Analytic Approach for Examining PSTs' Responses to MDPTS

We recently collected audio recordings and written work of 15 small groups (2-4 undergraduates in each group) of PSTs engaging with a set of four MDPTS, including the one presented in this paper. We started the process of open coding, reducing data, and articulating a preliminary analytic approach (Saldaña, 2013).

In Figure 2, we provide a few data excerpts of statements made from one group of PSTs during the activity and our tentative codes for those utterances. These data examples are not meant to be "final products," instead they represent our initial step toward a systematic and rigorous analysis and interpretation of our data. We include them to illustrate the range of codes that might be possible that highlight the multiple intersecting discourses elicited from one group of PSTs in response to "Mathematical Equivalence."

PST 1: [*responding to prompt no. 2 in Math Eq.*] It came about because Pat told them it was super easy. PST 3: [1]They were all like Pat you're a jerk! Stupid idiot! PST 1: [2]Because saying it's easy is ob--like ob-ject-ive, right? PST 3: Yeah, objective.	[1]STUDENT BEHAVIOR - JUDGEMENT [2]OBJECTIVITY/ MASCULINITY
PST 2: 'Cause I mean they're like none of them are *wrong* because [3]eight plus five plus four is= PST 3: Is seventeen. PST 2: =seventeen.	[3]STUDENT MATH THINKING
PST 1: I don't know if Pat is a boy or a girl but I feel like if they're both boys [*lower volume*] it could have been [4]toxic masculinity. PSTs 2 & 3: [5][Laughing] PST 1: Just throwing that out there. PST 2: [5]Yeah!	[4]GENDERED DISCOURSE [5]JEST

Figure 2: Data with tentative codes for multiple discourses for a group of PSTs.

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