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Developing Learning Trajectories for Teacher Learning:
Learning Trajectories for Teachers

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ABSTRACT

Learning trajectories have been widely used in mathematics education to model student learning. While learning trajectories have been applied to student learning, they typically have not been used to model teacher learning. This commentary discusses specific considerations that emerged from undertaking the development of learning trajectories for teachers. The author focuses on the teacher learning trajectories (TLTs) developed by Project-SET, a NSF-funded project aimed at increasing teacher knowledge in statistics. While extending learning trajectories to teacher knowledge, this article argues that it is important to consider how existing teacher knowledge frameworks can be incorporated in the trajectories, how teachers can be active participants in the trajectory development process, and how TLTs might allow for pedagogy transfer to emerge.

KEYWORDS

Learning Trajectories, Mathematics Education, Teacher Preparation

INTRODUCTION

Learning trajectories (LTs) in mathematics education have been often cited as effective ways to model student learning. While the term "learning trajectory" is widely used, several definitions and interpretations of LTs exist (see special issue of Mathematical Thinking and Learning, 2004 for different descriptions and conceptualizations of LTs). Initially the term hypothetical learning trajectory was introduced by Martin Simon (1995) and described as "the learning goal, the learning activities, and the thinking and learning in which students engage" (pp. 133). Grounded in constructivist theory, learning trajectories connect students' thinking and learning for specific mathematical content with a conjectured pathway to move students through a developmental progression (Clements & Sarama, 2004). Learning trajectories offer both structure and responsiveness to students by outlining a sequence of concepts, sample problems, and teaching tasks (Simon & Tzur, 2004).

The LT construct has been conceptualized as a model for student learning and teachers need to translate such models into useful tools to help their teaching (Edgington et al, 2016). Edgington et al discuss how teachers can utilize student LTs in their teaching. While LTs are a popular research-based approach to model student learning, the development of LTs as a model for teacher learning is underexplored. In teacher preparation programs and professional development, teachers are learners themselves; thus, it is natural to extend LTs to teacher learning. While this extension seems obvious, this extension is not straightforward in practice.

The purpose of this paper is to argue that teacher learning trajectories (TLTs) are empirically different than LTs for students. In particular, this paper discusses three considerations that emerged

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while developing TLTs: (1) existing teacher knowledge frameworks can be incorporated into TLTs, (2) teachers themselves can be active participants in the development of TLTs, and (3) it is useful for TLTs to allow for pedagogy transfer moments to emerge.

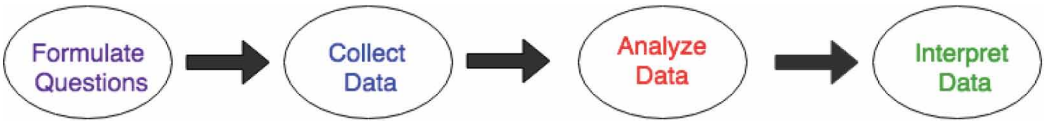
PROJECT-SET TEACHER LEARNING TRAJECTORIES

The basis of this paper comes from experiences in the National Science Foundation (NSF) funded Project-SET (grant no. 1119016). The four-year project developed two TLTs and designed a professional development program around the TLTs. The goal of Project-SET was to enhance teachers' content knowledge of two fundamental statistics topics – sampling variability and regression. The construction of the TLTs happened iteratively as the TLTs were refined after each professional development implementations (see Figure 3). Overall, the Project-SET TLTs were designed to conceptualize teacher knowledge in statistics. Project-SET then used these TLTs to design and structure a professional development curriculum.

Project-SET used Clements' and Sarama's (2004) conceptualization of a learning trajectory as a "learning goal, developmental progression of thinking and learning, and sequence of instructional tasks" to guide the TLT development. The learning goal of the Project-SET TLTs centered around teachers' content knowledge of sampling variability and regression. This learning goal was manifested through three design principles: (1) teacher learning should adhere to widely accepted models of statistics practice; (2) teacher learning should progress from informal notions of the content to formal understandings; (3) and teacher learning in statistics should incorporate the use of technology. These design principles guided the development of the progression and the instructional tasks.

Several papers and reports in the statistics education literature discuss models for statistical practice (Bargagliotti & Anderson, 2017; Franklin et al., 2007; Wild and Pfannkuch, 1999). Project-SET used the model presented by Franklin et al. (2007) in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Pre-K12 Report. The GAISE model articulates the statistical process in four components: formulate questions, collect data, analyse data, and interpret data (see Figure 1). The progression of the TLT was then organized around the components of this statistical process.

Figure 1. Model for the statistical investigative process used by Project-SET



With respect to the notion that teacher learning should progress from informal thinking about the content to formal procedures and ideas related to the content, much literature in statistics education has presented the case for focusing on statistical reasoning and steering away from procedures and calculations (Makar & Rubin, 2009, Bakker & Gravemeijer, 2004; Zieffler, Garfield, delMas, & Reading, 2008). As informal reasoning helps construct intuition, it develops conceptual understanding that would later be beneficial when learning formal procedures. This design principle was conceptualized in the developmental progression as a "loop," where a loop would work through each of the four components –formulate, collect, analyse, interpret. The sampling variability TLT consisted of six loops and the regression TLT consisted of five. As a result, teachers moving through the progression had to "loop through" the investigative process multiple times— 6 times for sampling variability and 5 times for regression. For example, for sampling variability, teachers proceeded