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Supporting children to construct evidence-based claims in science: Individual learning trajectories in a practice-based program

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HIGHLIGHTS

- Supporting construction of evidence-based claims is a complex teaching practice.
- Preservice teachers developed this practice across a practice-based program.
- Emphasis on coherence across courses seemed to support learning teaching practice.
- Variation existed across and within the preservice teachers' learning trajectories.
- Pedagogies of professional practice seemed to support the learning trajectories.

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ABSTRACT

New reforms envision ambitious teaching, requiring knowledge and abilities beginning teachers may not have. To support learning to teach, a practice-based approach has been suggested. This study examines four preservice teachers' learning pathways for one science teaching practice, *supporting students to construct evidence-based claims*, during a two-year practice-based teacher education program. Analyses uncovered variation and similarities across and within the teachers' pathways. For example, one teacher provided inconsistent support for elementary students to analyze data, whereas another developed sophisticated support. The findings suggest that elements of the program, such as coherence, facilitated the learning, having implications for teacher educators.

1. Introduction

New reforms, internationally, envision deep learning across subject areas. For example, students are expected to engage in science practices (e.g., conducting investigations, constructing evidence-based claims) to learn the big ideas in science (e.g., Australian Curriculum, Assessment and Reporting Authority (ACARA), 2013; National Research Council (NRC), 2012; United Kingdom Department for Education, 2014). This learning requires ambitious teaching as teachers coordinate interactions with content, students, and contexts to support all students' learning (Lampert, 2001). Learning to teach in these ambitious ways is complex and challenging (Feiman-Nemser & Buchmann, 1985; So & Watkins, 2005; Thompson, Windschitl, & Braaten, 2013). Specifically, beginning teachers must learn the knowledge, abilities, beliefs, and practices involved in ambitious teaching (Abell, 2007; Davis, Petish, & Smithey, 2006; Feiman-Nemser, 2001; Ogunniyi & Rollnick, 2015; Treagust, Won, Petersen, & Wynne, 2015). Teachers' probable lack of prior experience with this type of learning can make it difficult for them to envision this work (Evagorou, Dillon, Viiri, & Albe, 2015; Lortie, 1975; Treagust et al., 2015). Elementary teachers face additional complexity in learning to teach as they are expected to be experts in each subject area (Appleton, 2007).

Teachers can develop their knowledge and abilities for teaching over time, beginning with coherent teacher education programs that connect learning of theory to clinical field experiences (Dewey, 1965, pp. 140–171; Feiman-Nemser, 2001; Grossman & Richert, 1988; Hammerness, 2006; Nilsson & Loughran, 2012; Tang, 2003; Treagust et al., 2015). However, more insight is needed about how teachers' practice and knowledge develop over time. This

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study attempts to help fill this gap through exploring how new teachers learn to do this work during a two-year teacher education program.

Within science, exemplars of beginning elementary teachers' implementing reform-oriented practice exist; however, these teachers' ability to implement reform-oriented science varies (Avraamidou & Zembal-Saul, 2010; Forbes & Davis, 2010). This variation appears to be connected to many factors, including the individual's beliefs, knowledge, and orientations; mentors' knowledge and beliefs; and the context of the school (Abell, Park Rogers, Hanuscin, Lee, & Gagnon, 2009; Davis et al., 2006 Nowicki, Sullivan-Watts, Shim, Young, & Pockalny, 2013; Roehrig & Luft, 2006; Van Driel, Berry, & Meirink, 2014). Beginning teachers' experiences and learning in teacher education programs also influence their practice (Ross & Cartier, 2015; So & Watkins, 2005; Treagust et al., 2015; Zembal-Saul, 2009). For example, learning opportunities focused on evidence and explanation during university courses may have influenced a teacher's ability to use appropriate science language in her classroom teaching (Avraamidou & Zembal-Saul, 2005).

To support teachers in learning to teach, a practice-based approach that emphasizes doing the work of teaching along with developing knowledge for teaching has been suggested (Ball & Forzani, 2009; Grossman, Hammerness, & McDonald, 2009). This approach to teacher education has shown potential to support secondary science teachers' learning over several years (Janssen, Westbroek, & Doyle, 2014; Thompson et al., 2013). Studies have also considered how this approach might support elementary teachers in the context of one science methods course (Benedict-Chambers, 2016), yet none have explored how individual elementary teachers might develop a specific teaching practice during a practice-based teacher education program.

This study aims to further the field's understanding of how preservice teachers' practice and knowledge for teaching elementary science changes during a practice-based elementary teacher education program. Focusing on one high-leverage science teaching practice, *supporting students to construct evidence-based claims of natural phenomena*, this study examines the learning pathways of preservice teachers (called interns in this study) over two years. In this practice, teachers facilitate students to analyze data and use this data as evidence to make, support, and communicate claims about phenomena (e.g., predator-prey relationships). We ask:

- How do interns' practice and corresponding knowledge change over time in a practice-based teacher education program?
- How do interns describe how and why their knowledge and practice change over time?

We use a qualitative case study methodology to allow for close analysis of the development of a teaching practice over time.

2. Theoretical framework

2.1. A practice-based approach

This study uses an understanding of teaching as practice. In this view, practice and theory can be seen as intertwined in an "adaptive expertise" that allows for the use of "theory-in-action" (Hammerness et al., 2005; Schön, 1983). Rather than positioning practice in opposition to theory, we view teaching practice as the use of knowledge in action as teachers interact with students in a classroom. We draw on Lampert's (2010b) meanings of *practice*, focusing on the meanings of "a collection of practices," "to practice," and "the carrying on or the exercise of a profession or occupation" (Lampert, 2010b, pp. 5, 7, and 9). Table 1 provides examples of these meanings of practice for teacher education and science, which we also view as a practice.

We view learning the practice and knowledge of teaching as the process of moving from being an outsider of a community of practice to becoming part of the community of practice (Lave, 1996; Putnam & Borko, 2000). The process of learning is distributed across people and tools, situated in a particular context, and social (Putnam & Borko, 2000). This process of learning can be facilitated by a knowledgeable other (e.g., a teacher educator or mentor teacher) (Vygotsky, 1978). This learning occurs over time and may vary based on the prior views, knowledge, experiences, and learning opportunities of the individual (Anderson, Smith, & Peasley, 2000; Rivero, Azcárate, Porlán, Martín del Pozo, & Harres, 2011; Schneider & Plasman, 2011; So & Watkins, 2005), as the learner develops facility with using knowledge in action.

To support teachers' learning, a practice-based approach draws on pedagogies of professional teaching practice (Grossman, Compton, et al., 2009). When *representing the practice,* a teacher educator might discuss videorecords of exemplary teaching to make particular aspects of the practice visible (Grossman, Compton, et al., 2009; Little, 2003). *Decomposing* the practice into smaller pieces involves describing the elements of a particular practice such as giving an explanation (Janssen, Grossman, & Westbroek, 2015; Grossman, Compton, et al., 2009). Preservice teachers might *approximate the practice* through rehearsals of aspects teaching (Ghousseini & Herbst, 2016; Grossman, Compton, et al., 2009). Research suggests that having coherent, nested opportunities to discuss representations of practice, decompose element of practice, approximate the practice, and reflect on their practice and knowledge facilitates teachers' development (Boerst, Sleep, Ball, & Bass, 2011; Thompson et al., 2013).

In a practice-based approach, the pedagogies of professional practice facilitate learning of a set of high-leverage teaching practices (e.g., *leading a discussion* or *supporting students to construct evidence-based claims*) and the development of knowledge for teaching (Ball, Sleep, Boerst, & Bass, 2009). Ball and colleagues' (2009) criteria for selecting a high-leverage practice includes considering the centrality, frequency, applicability, and effectiveness of the practice. In addition, a novice could be taught, could rehearse, and could increase in proficiency in a high-leverage teaching practice (Ball et al., 2009). In science teaching, supporting students to construct evidence-based claims can be seen as a high-leverage practice,[1] given its role in promoting science learning (NRC, 2012) and evidence that novices can develop proficiency in the practice over time (Avraamidou & Zembal-Saul, 2005).

Knowledge for teaching includes pedagogical knowledge, knowledge of context and students (e.g., issues of diversity, knowledge of individual students' lives), and knowledge of the content (Abell, 2007; Shulman, 1986; Van Driel et al., 2014). Shulman (1986) described two types of content knowledge: subject matter content knowledge and pedagogical content knowledge. In science education, this subject matter content knowledge includes substantive knowledge about the body of knowledge of science and syntactic knowledge, an understanding of the scientific practices of a discipline and how they are used to develop scientific knowledge (Magnusson, Krajcik, & Borko, 1999; Schwab, 1964). Teachers develop and integrate this knowledge over time through

[1] Supporting students to construct evidence-based claims may be considered a smaller practice within larger grain-size core science teaching practices described by others for the secondary level including "engaging students in investigations" (Kloser, 2014) and "helping students make sense of material activity" (Windschitl, Thompson, Braaten, & Stroupe, 2012). We focus on smaller grain-size teaching practices in line with the practices emphasized by our program (cf. Davis & Boerst, 2014).