Syntactic Knowledge in History and Science Education:
Teacher Education and Neglect in the Academy

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Introduction

What does it mean to be a generalist? The term generalist is often used in the teacher education literature to describe the preparation of elementary teachers because they are prepared narrowly across a breadth of disciplines, rather than in any one discipline in-depth. However, this same literature struggles to conceptualize an "essential knowledge base" for teaching (Cochran-Smith & Zeichner, 2005). If we cannot clearly identify and articulate what teachers prepared within specific disciplines need to know and be able to do, what does it mean to be prepared across multiple disciplines? Although elementary school teachers are prepared as generalists, they still need a strong grounding in disciplinary ways of knowing (Grossman, Schoenfeld, & Lee, 2005) and be able to use that knowledge to develop powerful content representations that support meaningful student learning. Unfortunately, how teacher education programs support the development of this knowledge is fraught with difficulties. Teacher education has been characterized as fragmented and disconnected because coursework and classroom practicum experiences are often separate, courses are divided to address different professional skills, and courses taken in the arts and sciences are isolated from education courses—leaving the prospective teachers to bring it all together and make it meaningful in school classrooms (Darling-Hammond, 2006).

While this paper focuses primarily on the role of the preparation of disciplinary knowledge in elementary teacher education, this attention

is not meant to detract from the notion that teacher development also needs to be rooted in the knowledge of children's developmental, social, and cognitive abilities. One of the greatest challenges in teacher education is bridging understandings of the content with those of children (Darling-Hammond, 2006). Aspects of subject matter knowledge are critical to developing pedagogical content knowledge and therefore have an important place in courses related to the teaching of subject matter (Grossman et al., 2005).

Theoretical Base

Teaching is a complex action that is purposeful, yet dynamic and responsive to the classroom environment, the learners, and the subject matter. Teachers must rely on multiple knowledge bases to make daily decisions in their classrooms (Darling-Hammond & Bransford, 2005). It is generally agreed that effective teaching broadly requires foundational knowledge of learners and learning, pedagogical strategies and assessment, educational context and curriculum, as well as the subject matter to be taught (Grossman, 1990; Magnusson, Krajcik, & Borko, 1999; Shulman, 1986, 1987; Smith, 1999). In other words, effective teachers know more than their disciplines and more than good instructional strategies.

It goes without saying that teachers need to understand the subjects they teach, however, what they need to know to teach at various levels, as well as what the appropriate outcomes should be, is still a point of discussion (Evans, 2004; Floden & Meniketti, 2005; Grossman et al., 2005). Researchers and educators may generally agree that robust subject matter knowledge is important, but disagree about what specific knowledge within the disciplines is essential (Evans, 2004; Floden & Meniketti, 2005; Shulman, 1987). This presents an interesting dilemma given recent literature that is clear about school children's reasoning abilities and, therefore, how they should learn within certain disciplines (NRC, 2007; Evans, 2004; NRC, 2008; VanSledright, 2002).

In what follows we use science and history education to illustrate what happens in teacher education programs in these areas and is the result of the authors' attempts to bridge these disciplines in the context of concurrent science and social studies methods courses (Haefner & Slekar, 2006, 2008; Slekar & Haefner, 2007). It does not assume that history is exhaustive of all the other disciplines of the social studies. Rather, history and science are being used to illustrate what happens when a rich experience with these disciplines is neglected in teacher preparation programs.

Science and History Education

While the term "inquiry" is not new to any discipline, we need to be clear about what it means in science and history. Systemic initiatives of the 1990s emphasized the role of scientific and historical inquiry (NCSS, 1997; NRC, 1996). In particular, the NCSS National Standards for Social Studies Teachers (1997) called for a more disciplinary approach and suggested learners engage in examining historical primary documents, identify gaps and contextualize available records, and construct evidence-based interpretations of historical events. Similarly, the National Science Education Standards (NSES) (1996) also proposed a vision of scientific inquiry where learners were engaged with testable questions and required to give priority to evidence when developing explanations for scientific phenomena. Both documents emphasized learners become familiar with modes of inquiry and rules of evidence. This goes beyond a colloquial use of the term inquiry as simply asking and pursuing answers, to include a systematic approach to analyzing and interpreting data and developing evidence-based explanations. These systemic initiatives, while not without controversy (Evans, 2004), provided the framework for the state-level standards movement and school curriculum change.

While the standards movement was historically important, more recent documents in science education draw on research on learning and cognitive development and place greater importance on the cognitive abilities of children and what it means to be proficient in science (NRC, 2007, 2008). Current thinking goes beyond skillful performance and values the understanding and application of knowledge in ways that learners,

> appreciate the foundations of knowledge and consider the warrants for knowledge claims. Accomplished learners know when to ask a question, how to challenge claims, where to go to learn more, and they are aware of their own ideas and how these ideas change over time. (NRC, 2007, p. 19)

While the terminology across these disciplines is similar, the process by which knowledge and theories are developed can differ across disciplinary domains. We acknowledge that processes in earth science may differ from those in life science, and likewise, processes in history are different than geography. However, we argue that across domains and disciplines evidence is a common feature and holds a primary role in knowledge development, even though the rules of evidence and explanation may differ. The issue of "what counts" as data and the process of data analysis or model building to test hypotheses can vary. It is these subtle, but foundational differences that require a depth a disciplinary

knowledge not addressed in elementary teacher education. When preservice elementary teachers are bombarded with the same terminology across disciplines, how can these "generalists" be expected to understand and differentiate the norms of the disciplines?

Substantive and Syntactic Knowledge in Teacher Education

In science and history, preservice elementary teachers often take introductory survey courses offered by arts and sciences departments "across campus" that focus on a breadth of knowledge. In this setting, students become accustomed to receiving and memorizing information (McDermott, 1990; Stoddart, Connell, Stofflet, & Peck, 1993). Learning in this setting represents a focus on what Schwab (1978) described as the substantive structures of the disciplines, or the ways in which concepts and principles are organized within a discipline. Ball and Cohen (1999) argue that to overcome this foundation for the apprenticeship of observation, prospective teachers must learn content in ways that reflect the ways in which they are expected to teach. Specifically, they suggest the "development of subject matter that emphasizes the reasoning and 'meanings and connections' specific to each field" (as cited in Darling-Hammond, 2006, p.194). This approach is more consistent with syntactic structures of the discipline, or the ways in which truth, falsehood, validity and invalidity are established (Shulman, 1986). Shulman described syntactic structures like grammar- "it is the set of rules for determining what is legitimate to say in a disciplinary domain and what 'breaks' the rules" (p. 9). When the syntactic knowledge is omitted from science and history, missing are aspects associated with the nature of the disciplines. As a result, learners are left unsure of how knowledge is constructed within the norms of the disciplines. If learning about the nature of the discipline is left out of the subject matter courses taken by preservice teachers, where are the opportunities to learn it?

In teacher preparation, it is typically assumed that content courses prepare preservice teachers in subject matter knowledge and education courses prepare them in pedagogical knowledge. This pedagogical knowledge should include not only general pedagogical knowledge (i.e. classroom management, instructional principles, educational goals) but also subject-specific pedagogy or what is commonly referred to as pedagogical content knowledge (Shulman, 1986, 1987). Unfortunately, research in science education suggests that the primary emphasis has been on the development of pedagogical knowledge for teaching the substantive aspects of knowledge (Smith, 1999; Zembal-Saul, Blumenfeld, & Krajcik, 2000). This suggests that not only has the syntactic structures

of the discipline been omitted from the subject matter courses, it has also been left out of the teacher preparation courses.

So what do preservice teachers know about the subjects they teach? In general the literature suggests they are not prepared in the subjects they are expected to teach. According to Floden and Meniketti (2005),

> a significant number of prospective teachers have only a mechanical understanding of the subject they will teach. They know 'rules' to follow, but cannot explain the rationale behind the rule. Some invoke inaccurate 'rules.' If the ability to explain basic concepts important for teaching, then the subject matter courses teachers now typically take leave a large fraction of teachers without important subject matter knowledge. (p. 283)

Unfortunately, this is not a new revelation. For years researchers in many disciplines have suggested prospective teachers hold limited understandings of subject matter (Abell & Smith, 1994; Anderson & Mitchener, 1994; Ball, 1990; Bloom, 1989; Clement, 1982; Hauslein, Good, & Cummins, 1992; Kennedy, 1998). The limitations to prospective teachers' knowledge of science are not limited to basic concepts, but also include the understandings of the nature of science (Abell & Smith, 1994; Hauslein et al., 1992; Lederman, 1992, 1998). In addition, studies (Abd-El-Khalick, 2001; Akerson, Abd-El-Khalick, & Lederman, 2000; McComas, 1996) have reported that preservice teachers believe scientists are objective and do not consider how their background and experiences may lead them to differing interpretations of data.

Research in history education also reports limitations of preservice teachers' knowledge of the discipline as history is seen simply as something that happened in the past (McDiarmid, 1994). It has been reported that preservice teachers struggle to grasp the interpretive nature of historical narratives (Wineberg, 2001) and view them as lacking a process for verification (McDiarmid, 1994). Moreover, the disciplinary knowledge of history that teachers need in order to think about the teaching of history as a process of inquiry is typically not developed during a teacher's time in teacher education programs (Slekar, 1998; VanSledright, 1996). Similarly, while learning to support children's historical inquiry, it has been suggested,

> even when confronted with powerful courses that challenge them, preservice teachers tend to think differently and usually only learn to 'talk the talk.' The 'walking' part—teaching history as an inquiry process—is often clumsy and the preservice students often appear paralyzed. (Slekar, 2006, p. 237)

Children and Knowledge

It stands to reason that if preservice teachers struggle to understand subject matter and the norms of disciplines, then perhaps the reform documents are asking too much- both of teachers and students. However, empirical research informs us of school children's ability to learn to think historically and engage in scientific inquiry (NRC, 2007; Hapgood, Magnusson, & Palinesar, 2004; NRC, 2008; VanSledright, 2002). More importantly, it informs the ways in which school children come to make sense of evidence in science and history, as well as how both disciplines have similar, but distinct rules for interpretation (Geire, 1997; Metz, 2004; Wineberg, 2001). According to this research, children are capable of understanding these rules, but it requires a reformation of the view of traditional content and teaching methodologies (Darling-Hammond, 2006; NRC, 2007; Hartzler-Miller, 2001; Metz, 1997, 2004; NRC, 2008; VanSledright & Afflerbach, 2000) as well as beliefs about children's abilities to reason (Metz, 1995, 2004).

Discussion

Understanding children's abilities within disciplines leads one to assume that expectations for preservice teachers should flow from this research. After all, teacher educators need to make sense of the available literature when designing and teaching courses for preservice teachers. There ought to be fidelity between a teacher educator's expectations for children's learning in the disciplines, what is known about children's capabilities within the disciplines, and how preservice teachers are prepared to support children's learning (Bain, 2000). Therefore, isn't it reasonable to expect methods courses to attend to the role of evidence, interpretation, and explanation in history (Hicks, Doolittle, & Lee, 2004; Seixas, 1998) and science (Metz, 1997) so that preservice teachers' classroom practice supports the development of these ways of knowing in children?

But what about the subject matter courses? Given preservice elementary teachers' limited understanding of subject matter, asking them to develop learning experiences for children that differentiate the rules of the disciplines is a tall order. While research suggests preservice teachers can understand important aspects of evidence (Haefner & Slekar, 2008), this does not account for their ability to translate these understandings into practice. Moreover, learning complex aspects of the subject matter cannot wait until methods courses (Akerson, Morrison, & McDuffie, 2006; Haefner & Slekar, 2008). Preservice teachers need to learn subject matter in ways that represent both the substantive and syntactic aspects of the disciplines. Therefore, we strongly suggest the subject matter courses

that service prospective teachers devote a portion of their coursework to developing understandings of syntactic knowledge, perhaps at the expense of some substantive knowledge. According to Floden and Meniketti (2005) research in this area is essentially non-existent and teacher educators know very little about prospective teachers' syntactic understandings of the disciplines they will be expected to teach.

We suggest that if history and science educators value teaching and learning syntactic aspects of the disciplines, then it is essential to pay more attention to the types of content knowledge prospective teachers hold upon entering teaching and learning courses. When teacher education uses the same terminology such as inquiry, data, evidence and explanation, preservice teachers may not develop understandings in appropriate contexts. More often than not they may fail to develop understandings that enable them to differentiate fundamental aspects of knowledge claims.

Conclusion

This paper argues that in order to create powerful learning experiences rooted in the disciplines, much more cooperative work is needed across methods courses, as well as across colleges. Teacher preparation is not just the responsibility of education programs. If prospective teachers have opportunities to consider the ways of thinking within different disciplines as they take their arts and sciences courses, when they enter certification programs they can begin to consider the pedagogical relationships between different subject matters (Grossman et al., 2005). In particular, we believe teacher educators needs to look deeply at how this is accomplished in elementary certification programs. As a community, we have made considerable progress in understanding children's cognitive and reasoning abilities within the disciplines. Unfortunately we have done little to support prospective elementary teachers' reasoning abilities within the disciplines. If it isn't part of their teacher education, how will they be prepared to teach children in this way?

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