

INTRODUCTION

Practice-Based Science Teacher Education

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During a recent methods class in a university-based teacher preparation program, a team of four preservice teachers was leading an investigation about the effects of weathering on rocks. These team members were the lead instructors during an extended pedagogical rehearsal in which their peers—fellow preservice teachers in the same methods class—participated as students during the lessons. Prior to the current rehearsal, the preservice teaching team facilitated a lesson in which students shook jars containing rocks and different liquids to investigate how rock structure changes because of physical and chemical changes.

Unbeknownst to the preservice teacher instructional team, one group of students had hidden a jar with water and rocks on a windowsill over the weekend, hoping to observe if any changes occurred to the rock given longer exposure to water. This secret action became meaningful when the instructional team began a whole-class discussion about rock sediments during the weathering lesson. Suddenly, a student interrupted the conversation to say, “Oh wait, is our cup still in here?” Immediately, multiple students echoed her question: “Oh yeah, is that jar around?” “Oh, right, is the jar here?” The preservice teacher instructional team, however, said nothing, as students scurried to retrieve the jar from the

window sill. A student placed the jar on a desk, and six other students gathered around to look, all stating observations and hypotheses about the rock. The instructional team, one of whom held an uncapped marker in her hand because she was writing down student thinking on a poster board, remained frozen at the front of the classroom while students excitedly shared ideas. Clearly, this was an unexpected moment of student talk and action, and the instructional team seemed stuck on how to proceed.

After one minute of overlapping talk, a student finally asked an instructor: “Do you have a picture of the other jars from last week?” At this question, the marker-holding instructor sprang into action, saying, “Yes, let me find one.” While this instructor found the photo on her phone, the students told their peers about the purpose of leaving the jar on the window sill. In addition, another member of the instructional team arrived at the table and asked a series of questions aimed at pushing the students to think more deeply about their observations. After a round of questioning, a third member of the instructional team yelled out, “Okay, let’s bring it back,” and all eyes returned to the front of the room and the poster board—the descriptions of student thinking still in mid-sentence.

After this lesson ended, the students had an opportunity to debrief with the instructional team about their pedagogical decisions, and as expected, questions quickly focused on the “hidden jar” episode. One question seemed especially important; a student asked, “Why did you find a picture of the jar rather than stop that talk?” The instructor paused, then replied, “I realized that I could help, and that it gave me a way to link a clear but unexpected student interest to the lesson we were trying to teach.” Then, turning to the teacher educators, that same instructor asked: “How do I do that better? How do I help students when they say something I didn’t expect? How do I show them that I want their ideas and their thinking?”

We present the “hidden jar” vignette to begin this book about core practices and practice-based science teacher preparation because the story illustrates the difficulty and importance of preparing preservice teachers to foster classrooms in which students feel safe, valued, and encouraged to take actions to advance their thinking. Two themes that emerge from the “hidden jar” story provide the foundation for this book. First, the preservice teachers in this story identify

important problems and opportunities of practice, and ask questions that reflect new science teaching and learning expectations (including policy documents such as the *K–12 Framework for Science Education* and the *Next Generation Science Standards*).¹ Rather than framing teaching as controlling students' thinking (e.g., fixing “misconceptions”) or regulating their every move (e.g., focusing on classroom management), the preservice teachers were learning core instructional practices aimed at building and sustaining collaborative learning communities in which students' ideas and talk are the driving force of teaching. Second, the “hidden jar” story embodies an opportunity designed by teacher educators for the preservice teachers to rehearse complex core practices in a setting that simultaneously is safe and presses the preservice teachers to think differently about teaching and learning. The teacher educators structured the methods class so that preservice teachers learned to value and attend to student thinking, to recognize and make principled decisions when encountering uncertainty, and to feel comfortable asking colleagues for help. In other words, the “hidden jar” story emerged from the teacher educators' purposeful design of learning opportunities for preservice teachers to develop a vision of equitable teaching, and to rehearse core practices in a methods course.

As a community of teacher educators, we recognize that designing such opportunities for preservice teachers is crucial, but difficult. In addition, conversations among teacher educators about their pedagogies, innovations, and learning opportunities are not often elevated to public planes of discussion. Therefore, this book embodies our aim as a community of colleagues to continually and collectively improve our work as teacher educators to better prepare preservice teachers. This book is unique because we, as teacher educators in multiple preparation programs, are living the daily reality of preparing new science teachers while engaged in conversations across institutions. Through discussions over multiple years, we arrived at shared problems and opportunities of practice around teacher education: How do we help preservice teachers learn through practice-based teacher education? How do we advance as a community of teacher educators through scholarship and inquiry into our teaching? How do we learn with and from each other about practice-based teacher preparation, and continually improve our work as teacher educators? Throughout this book, we will tell stories of our collective learning as well as consider how we can continue to improve our teaching and research.

PRACTICE-TEACHER PREPARATION

Educators are being asked to reimagine teaching to support the learning of all students by engaging them in cognitively demanding tasks that are authentic to disciplines. This teaching has been described as *ambitious* because of its attention to eliciting and supporting *all* students' thinking as the foundation of ongoing sensemaking while they participate in learning activities.² Note that such instruction differs from other notions of science teaching, such as 5E, inquiry or "hands on," and project-based teaching, through its emphasis on students' participation in and shaping of science practices, as well as on classrooms that use students' ideas as the foundation of the learning community.

Concurrent with the emerging understanding of teaching and learning, the field of teacher education has undergone a major shift in thinking about how preservice teachers can learn about instruction. There has been a move away from a focus on developing teacher knowledge in various forms, and toward the enactment of core teaching practices based on a growing body of research about how students learn.³ The term *core practices* as used here draws upon the definition proposed by Windschitl and Calabrese Barton:⁴

By teaching practices we mean the recurring professional work devoted to planning, enacting, and reflecting on instruction. We emphasize teaching as practice as a way to acknowledge that student participation and learning are mediated most directly by teacher decisions about the kinds of tasks, talk, and tools used in the classroom. Without some common framework to describe and guide good teaching—as practice—it is difficult for either researchers or practitioners to communicate about meaningful classroom problems, and it is especially difficult for professional knowledge to be shared, tested, and refined over time.

Focusing on core practices and practice-based teacher preparation addresses what Kennedy refers to as the "problem of enactment."⁵ In brief, the problem of enactment describes the difficulties preservice teachers encounter when trying to align concepts and principles they are learning from reading about, watching, and discussing teaching with the daily work of teaching actual students. Grossman and McDonald have argued for an approach to address the problem of enactment by characterizing the ways in which teacher educators can engage preservice teachers in learning opportunities to take up ambitious practices in the classroom.⁶ They suggest teacher educators employ wide repertoires of teacher education pedagogies to support preservice teachers in investigating

teaching and learning, situated in artifacts of practice such as case-based learning; examining lesson plans and student work; and using video of classroom instruction. However, while these approaches can impact how new teachers talk about practice, what is less well understood are the ways teacher educators can effectively prepare preservice teachers to enact and adapt these practices. Grossman and McDonald refer to this as a move from pedagogies of investigation to pedagogies of enactment.

We propose that a practice-based approach to teacher preparation organizes the work of teaching and teacher education around core practices of K–12 instruction and uses an ensemble of teacher educator pedagogies, such as representing these practices, engaging preservice teachers in rehearsals of these practices, and coaching in clinical settings, to support the approximation of complex forms of teaching over time by novices. These core practices differ across disciplinary areas as well as research groups; however, they are potentially powerful resources for helping shape more systematic preparation of preservice teachers because they are specific characterizations of everyday aspects of teaching that maintain the complexity of classroom interactions by allowing for professional judgment rather than demanding a strict adherence to scripts or routines. Importantly, teacher educators are also trying to help preservice teachers develop conceptual frameworks for teaching, which provide a rationale for and an intellectual understanding of practice. Thus, practices are represented, decomposed, and approximated, and preservice teachers engage in deep intellectual work to develop a conceptual understanding of good teaching.⁷

For preservice teacher educators, a focus on core practices is one way to make visible a skilled core of teaching.⁸ The professional work associated with ambitious teaching becomes more easily appropriated by preservice teachers when it is framed as a set of practices that are explicit, principled, and adaptable to different instructional settings. Just as important, variations of core practices allow teacher educators to spend more concentrated time representing these practices, identifying other resources linked with these practices (tools for use in the classroom, videos of enactments of these practices in classrooms, samples of student work as the outcomes of these practices, etc.), having preservice teachers rehearse these practices and get feedback, and trying out the practices in classrooms. Thus, a practice-based approach might advance teaching and teacher preparation through careful experimentation and feedback to the professional preparation community.

Teacher preparation in a sociopolitical context

While we advocate for and study practice-based teacher preparation, we recognize that teacher education exists in a sociopolitical context in which there are questions raised about the value of teacher education. Specifically, there has been a rise in a free market ideology suggesting that teacher preparation should become a marketplace in which certification is commodified. Our worry is that an approach to teacher preparation that is eager to quickly certify teachers will sacrifice opportunities for preservice teachers to make sense of educational theories and practices and to participate in pedagogical rehearsals. We recognize that a common critique of teacher preparation programs is that there is insufficient evidence to support claims about teacher success. Therefore, we propose that it is incumbent upon teacher educators and teacher education scholars to continue conducting in-depth research that helps us better understand how practice-based teacher preparation may support the goals of public education, and may further help students who are already being taught by underprepared teachers and/or are learning in schools that those with power choose to marginalize.

Inspired by the multiple conversations around teacher preparation occurring among teacher educators, policy makers, parents, teachers, and school/district administrators, this book represents the genesis of a community of colleagues aiming to articulate what we have learned about practice-based science teacher preparation, and to advocate a stance of collaborative learning as we advance together. We are a group of teacher educators who are actively teaching and examining our instruction using shared language, practices, and tools. Our goal is to tell the story of how a community of colleagues can generate, test, revise, and disseminate research about core practices and science teacher preparation. In addition, we aim to be candid about our work—what fits and starts have we encountered, what puzzles and concerns us, what we are learning, and what we want to work toward as we prepare the next generations of professionals.

SIX PRINCIPLES ANCHOR THIS BOOK

To tell our stories, this book is anchored around six principles that are reflected in our research and work with preservice and in-service teachers.

Principle 1. Teaching is not natural, not magic, nor is anyone “born to teach.” Instead, teaching is a learnable profession in which preservice teachers develop knowledge, practices, identities, and agency to launch their careers.

During science teacher preparation, preservice teachers also learn to empower students to participate in, question, challenge, and reshape the cultures of science and school.

Principle 2. A key feature of classrooms in which students reshape school and science cultures is that their ideas and experiences are the primary drivers of teaching and learning opportunities. Teachers help orchestrate multiple forms of student talk and sensemaking that are often constrained by the norms and values of schools, which frequently value the recitation of information. As teacher educators, we want to provide opportunities for preservice teachers to reimagine their image of productive talk in classrooms, and to rehearse the orchestration of such talk during preparation programs.

Principle 3. As a community of teacher educators, we are engaged in purposeful and productive learning with and from each other about science teacher preparation. We embrace an inquiry stance about our teacher education pedagogies, and talk in a tone of curiosity about our work. We are never finished learning. This book represents where we have been and where we are now, and previews where we hope to go to better prepare science teachers.

Principle 4. An important reason why we can grow as a community is that we use and adapt a shared pedagogical language, practices, and tools. We have common instructional objects to work with and on, thus enabling us to produce knowledge about teaching that can be developed and shared across preparation programs. In addition, we learn with and from our current and former preservice teachers as they try out, adapt, and create practices and tools in classrooms. This cycle of preparing teachers and learning with and from them, their students, and their communities creates a group of colleagues who are engaged in collective work to improve science teaching and learning.

Principle 5. These shared practices, which we describe as core practices (see the definition in the next section), are *not* “best practices.” For our community, the term *best practices* implies a false narrative about teaching—that ideal or perfect instructional practices exist that teachers can use regardless of context to guarantee all students’ achievement. We argue that “best practices” are too vague, prescribed, individual (i.e., not connected to a larger framework of instruction), and perpetuate inequities. In contrast, our framing of core practices is that they are designed and adapted by teachers, grounded in research on student learning, connected to short- and long-term instructional goals, provide teachers with concrete features to

work toward equity and justice in classrooms, and prioritize the building of relationships with students. The core practices described in this book provide a picture of our collective and current thinking about teaching and teacher preparation. Our stance is that the naming and reification of practices is important because the practices can then be discussed, investigated, improved, and adapted. Importantly, reification is not canonization—the core practices described here are not settled and finished. Core practices constantly evolve through collaboration and collective investigation and learning from practitioners and communities.

Principle 6. Preparing preservice teachers to work toward equity and justice in classrooms requires the development of a critical consciousness *and* core practices. Neither a critical consciousness nor core practices—if separate from each other—can help preservice teachers learn to become the teachers that students need. Learning instructional practices without developing a critical consciousness means that preservice teachers might devalue the relational and humanizing features of their daily work, and might think that their job is to uncritically move through a list of routines without considering students' lives, experiences, identities, and needs. Conversely, preservice teachers need reified and learnable examples of equity and social justice practices that they can begin to learn and rehearse in preparation programs. We should not hope or assume that preservice teachers will develop equitable instructional practices or work toward justice in classrooms without support. We should also not require that preservice teachers shoulder the sole responsibility for creating pedagogies to disrupt systemwide inequities. If left to create teaching practices individually, or faced with the task of changing the culture of a school, we worry that many preservice teachers will default to enacting instruction that they experienced as learners, which likely perpetuates the very inequities we aim to disrupt. Therefore, teacher educators must help preservice teachers develop a critical consciousness *and* learn, use, and adapt concrete core practices that can provide a foundation to enact the important vision of equitable and just teaching.

KEY TERMS IN THE BOOK

As noted, one crucial reason for our collaboration is that we share language, practices, and tools around teacher education. We define some key terms here, and throughout the book, we describe how such terms are made actionable

and used with preservice teachers, mentors, and administrators of schools and universities.

Preservice teacher: Someone learning to become a teacher who is participating in a teacher preparation program and is not yet certified to teach.

Core practices: The adaptable pedagogical routines that preservice teachers learn to use in order to support students' ways of interacting with science and with each other. Core practices have six features: an instructional goal; a prototypical sequence of interaction with learners; tasks, characteristic talk, and tools; underlying principles that allow productive variations of practice; a recognizable role in a larger coherent system of instruction; and the expectation that they will be adapted through principled improvisation as they come into being during interactions. Importantly, core practices are made better as teachers and teacher educators learn with and from each other through the enactment of the practices with preservice teachers, students, teachers, administrators, and communities that schools serve.

Practice-based teacher education: A framing of teacher education that focuses on disrupting preservice teachers' images of science and teaching, learning core practices through multiple opportunities to rehearse teaching, and building relationships with students and their communities.

Pedagogies of teacher education: The learning opportunities designed by teacher educators for preservice teachers to learn how to enact core practices, how to build relationships with students and communities, and how to become a reflective teacher.

Ambitious Science Teaching (AST): A pedagogical framework that supports all students to engage in intellectually rigorous and equitable learning opportunities that are facilitated by core practices and tools. Ambitious Science Teaching represents one version of how core practices can be organized and learned by preservice teachers. Along with other versions of instruction that advance teaching and learning beyond memorization, AST offers powerful examples of how core practices can serve as the foundation for rigorous and equitable instruction.

Task, talk, tools: These refer to features of core practices that preservice teachers learn to pay attention to when planning and teaching. For the authors of this book, these terms mean:

- *Task*: Instructional episodes should include a complex and content-rich scenario and high expectations for student learning. Activities are designed in service of learning about overarching science ideas and supporting students in revising their ideas over time.
- *Talk*: Teachers and students should engage in purposeful talk with elaborating, questioning, and reorganizing of ideas as the goal; students' ideas are uncompromisingly treated as intellectual resources for everyone's learning.
- *Tools*: The unit and individual lessons should scaffold student and teacher reasoning. The tools should also help publicly represent student thinking.

Clinical experience: This refers to an opportunity for preservice teachers to spend time in a mentor teacher's classroom in which they have access to time, resources, and students in order to rehearse teaching. Clinical experience is a planned learning opportunity in many teacher preparation programs.

BOOK TRAJECTORY

The trajectory of this book aims to tell the story of our research and learning as a collaborative community of teacher educators. Importantly, the chapters represent the authors' joint research and teaching. In other words, as teacher educators, we simultaneously teach and study our methods courses and other learning opportunities for new and experienced teachers. This book provides us with an opportunity to share our collective scholarship and pedagogy with colleagues.

The foundation of our work is grounded in our perspectives on learning, so we begin by theorizing about how preservice teachers learn to teach in practice-based programs (chapter 1). Building on this foundation, we then describe AST as one instructional framework that was designed, and has been extensively tested, to help reify rigorous and equitable instruction for preservice teachers (chapter 2). However, we do not view AST as a static entity, and therefore, in chapter 3, we describe a critical area of growth around AST for our community, in which equity and social justice can be more specifically articulated in the preparation and instruction of preservice teachers.

To ground the principles and practices in specific examples, we then describe how teacher education pedagogies help preservice teachers focus on moment-to-moment interaction with students. Specifically, we begin by comparing two teacher preparation sites to examine differences in how they help secondary pre-

service teachers learn core practices (chapter 4). We then focus on one teacher education pedagogy involving an extended pedagogical rehearsal that occurs in one preparation program (chapter 5). We also examine the teacher education pedagogy in a methods course designed to support productive science talk in elementary classrooms (chapter 6).

After establishing how core practices and teacher education pedagogies look in both elementary and secondary courses, we then shift to examining practice-based teacher preparation from a programmatic perspective. We begin by describing how practice-based teacher preparation requires an asset framing of elementary preservice teachers with regard to supporting responsive teaching (chapter 7). Next, we describe how a teacher education institution took a program-level approach to core practices that were then specified for science (chapter 8). Continuing to examine program-level structures, we look at how practice-based teacher preparation is developed outside a traditional university setting in which Ambitious Science Teaching is addressed in multiple connected courses (chapter 9), and how secondary preservice teachers learn in a methods class embedded in a secondary school (chapter 10).

Finally, we examine relationships between practice-based teacher preparation and the contexts that support the learning of preservice teachers. Specifically, we examine the important relationship between mentor teachers and preservice teachers who learn in practice-based programs (chapter 11). We also consider how universities support and constrain efforts at practice-based teacher preparation through their structural and partnership choices (chapter 12). Finally, we describe how practice-based teacher preparation programs aim to impact larger organizational units, engaging with school districts to support core practices and organizational change around science teaching and learning (chapter 13). We conclude the book with a summary of key themes and potential avenues for future research, including how focusing on teaching practice can help preservice teachers focus deeply on student thinking and learning.