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Developing a Theory of Ambitious Early-Career Teacher Practice

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Current theories of novice teacher learning have not accounted for the varied influences of pedagogical training, subject matter knowledge, tools, identity, and institutional context(s) on the development of classroom practice. We examined how 26 beginning secondary science teachers developed instructional repertoires as they participated in two types of communities, one infused with discourses and tools supportive of ambitious teaching and another that reinforced traditional practices. We found three trajectories of practice—each with distinctive signatures for how novices engaged students intellectually. Differences were explained by: the communities with which teachers most closely identified, the degree to which teachers' discourses about student thinking were developed within these communities, and how teachers used tools from the communities to shape their practice.

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The earliest and perhaps most formative stages of a teacher's development are influenced by the "two-worlds" problem (Feiman-Nemser & Buchmann, 1985). Often novice teachers transition from preparatory settings, where coursework and other experiences are based on a learning-centered reform vision of instruction, to public school classrooms where mentors and colleagues may be unfamiliar with ambitious teaching practices and where the prevailing institutional discourses may work against such innovative practices (Anagnostopoulos, Smith, & Basmadjian, 2007; Kennedy, 1999; Zeichner & Tabachnick, 1981). Even when novice teachers are exposed to well-designed research-based conceptual frameworks about organizing instruction and analyzing classroom events, they will either not know how to enact these ideas when they enter a classroom or they will disregard these frames and rely on teacher-centered instruction (Bransford & Stein, 1993; Brickhouse & Bodner, 1992; Ensor, 2001). In the teacher education literature, these effects are broadly characterized as "problems of enactment" (Kennedy, 1999), when a teacher attempts to apply what was learned in preparation coursework to the complexity of public school classrooms during internships and beyond.

Even though the two-worlds problem is a simplified model of reality, it provides an effective initial frame for this research, which examines how novice teachers negotiate among different, often competing messages, norms, and practices in various learning-to-teach settings (we refer to these as *contextual discourses*) and how they individually develop discourses (*critical pedagogical discourses*) that define and shape their emerging repertoires of practice. We use sociocultural and narrative identity perspectives to describe teacher learning as the process of negotiating different types of contextual discourses—those focused on ambitious or conservative forms of teaching—concurrent with the development of teacher's individual critical pedagogical discourses. Few studies have traced the development of particular kinds of reasoning and ambitious practice across the institutional and social contexts that make up preservice preparation and the first year of teaching for individuals, nor have they convincingly accounted for the dramatic variability in instructional skills of beginning teachers who experience the same training (for exceptions, see Grossman et al., 2000; Horn, Nolen, & Ward, 2008).

Studies of novice teacher learning that attempt to explain differences in uptake of reform-based practice tend to fall into one of two categories: those that focus on the development of teacher knowledge and beliefs (e.g., Lee, Brown, Luft, & Roehrig, 2007; OECD, 2009) and those concerned with institutional characteristics, such as school climate (e.g., McGinnis, Parker, & Graeber, 2004). These factors have been associated with and predictive of reform-oriented practices by novice teachers. None however have been

integrated into a framework that explains why certain trajectories of practice unfold over time. Some researchers describe "typical" stages (e.g., Bullough & Baughman, 1997; Feiman-Nemser, 1983; Huberman, 1989) beginning with survival as new teachers resolve discipline and management problems, giving way to a focus on curriculum, then teaching practices, and only later on student learning (Liston, Whitcomb, & Borko, 2006). Other explanatory approaches rely on broad novice-expert comparisons (Berliner, 2004) or characterizations of beginning teachers' emerging identities (Flores, 2006; Gomez, Black, & Allen, 2007; Richmond, Juzwik, & Steele, 2011). Understanding the evolution of novice teachers' discourses and practices will promote theory development regarding why some individuals enter professional service with unusually sophisticated repertoires of practice and a willingness to continue learning while others are prepared only to execute unproblematic instructional routines. This knowledge is essential to the design of preparation and induction experiences for beginning teachers, informing for example the development of pedagogical tools and support mechanisms tailored to the needs of novice teachers.

We examined the developing practices of 26 secondary science teachers as they moved between two communities with different contextual discourses, promoting contrasting visions of science teaching. The school contexts in which novice teachers interned and carried out their first year of teaching overwhelmingly emphasized traditional teaching practices and curriculum coverage as a primary concern. In contrast, the university teacher preparation coursework and induction supports promoted specific ambitious teaching practices, focusing on student engagement and evidence of learning as fundamental to teaching. These latter practices were supported with specialized tools and socio-professional routines designed to further this intellectual work.

We sought to understand how and why beginning educators attempt to appropriate ambitious classroom practices during their internships and first year of professional work. We examined how they reasoned with competing contextual discourses *across contexts*—which we conceptualized not as an analysis of the static settings surrounding teachers' work, but as the ways that teachers make meaning of the dynamic interactions, norms, activities, and goals that emerge across time and settings (Duranti & Goodwin, 1992; Erickson & Shultz, 1981).

Specifically we asked the following:

Research Question 1: How are novices' trajectory of practice influenced by their own developing pedagogical reasoning about teaching and learning, as well as their participation in multiple professional communities that may have contrasting visions and messages about good teaching?

Research Question 2: How do tools and professional routines, used in different learning-to-teach settings, create opportunities and tensions for the early development of practice?

Studying the development of sophisticated forms of early teaching was our aim. Research on the development of these forms of teaching is intertwined with the search for effective ways to catalyze and support such practices; in our case through modeling new forms of instructional discourse, providing opportunities to approximate these practices, and creating conceptual and practical tools to guide the intellectual work of teaching (Grossman et al., 2009). Thus, we are specifically seeking to describe whether, how, and why early career expertise develops in concert with principled conditions of support.

Building a Theory of Novice Teacher Practice

To address the issue of how novice teachers develop different beginning repertoires, we adapted a framework by Hammerness, Darling-Hammond, and Bransford (2005). In its original form, the framework included five elements of teacher thinking and practice. Nominally, these include: learning to teach in a community that enables the development of a vision for practice; a set of understandings about teaching, learning, and children; dispositions about how to use this knowledge; practices that allow teachers to act on their intentions and beliefs; and tools that support their efforts. The framework synthesizes what the field postulates is important to teacher learning; however, it did not account for observed patterns in our research, including fluctuations in a teacher's professional "way of being," particularly during the early years, or tensions novice teachers experience in the appropriation of ambitious versus standard practices (Windschitl, Thompson, & Braaten, 2008).

We were particularly interested in how individuals make sense of contextual discourses about ambitious practices (emphasized in university and induction contexts) together with discourses about standard teaching practices (typical of practicum and first-year teaching contexts). Nolen and colleagues (2009) reported that during university coursework, preservice mathematics and social studies teachers constantly "filtered" the information and ideas presented, based on what they believed was important to learn, what kind of teacher they wanted to become, and the relative affinity they felt toward their methods instructors versus their cooperating teachers. Similarly, Horn and colleagues (2008) described how preservice teachers coordinated and adapted progressive practices (taught in a teacher education program) by putting them alongside other instructional strategies that were more familiar. The novices compared possible practices to their personal goals for teaching to determine which attributes of practices were worth taking up—given existing contextual influences within their school settings.

These and other studies suggest that the decision to take up progressive forms of instruction requires developing affiliations with people and ideas within and across communities (Boaler & Greeno, 2000; Gomez et al.,

2007; Wenger, 1998). While some studies follow the development of affiliations in terms of instructional goals, beliefs about teaching, or visions of practice, others have tried to specify which might be most influential on pedagogical reasoning—describing, for example, the powerful role of "personal commitments" (Rex & Nelson, 2004) and "personal biographies" (Flores, 2006) in everyday instructional decisions. Sfard and Prusak (2005) described how critical narratives are more consequential than other narratives for guiding actions; these "collections of stories about persons . . . that are reifying, endorsable and significant" (p. 16) develop through discursive interactions. In particular, narratives set in the future tense are more likely to guide learning as individuals move toward a future view of themselves. The challenge for novice teachers is that they must develop such narratives across settings with competing contextual discourses—that juxtapose status quo (conservative) forms of teaching and ambitious, progressive forms of teaching.

We used the concepts of critical pedagogical discourses—individual ways of thinking and being—and contextual discourses—historical, social, and institutional influences—to understand the development of teachers' language and practice as they encountered diverse images of professional work across communities. Critical pedagogical discourses and contextual discourses were conceptualized as interacting and together shaping practice across time (Rogoff, Baker-Sennett, Lacasa, & Goldsmith, 1995). We reasoned that teachers identify with others' stories of practice (e.g., from university instructors, cooperating teachers, department members) prior to and during teacher education and negotiate the appropriateness of new practices by evaluating the fit with their developing frameworks. If new practices that are modeled appear to be consonant with an underlying theory of teaching or present a compelling new vision, then the novice teacher may identify with stories from these influential narrators (Sfard & Prusak, 2005) and endeavor to appropriate the practice. If the novel practice appears incongruent with one's underlying theory of teaching, then the individual might simply nominally adopt the practice (Elmore, 2004), or they might modify their theories of teaching to create new visions of practice. Alternatively, the new practice may be rejected as incommensurable with an individual's theories or goals. Thus, through modifications to their vision of practice and through enactment of developing visions, novice teachers are able to justify existing frameworks, adopt new frameworks, or create hybrids to guide their practice.

Defining Critical Pedagogical Discourses and Contextual Discourses

Critical pedagogical discourses and contextual discourses merge sociocultural and narrative identity theory with theories of teacher development and provide a way to link teacher learning on an individual level with community influences. Critical pedagogical discourses are personal theories

about "what counts" as productive teaching and learning (Flores, 2006; Rex & Nelson, 2004). They are threads of internalized dialogue that constitute teachers' narratives about their current and future teaching selves. While individuals use a variety of narratives relating to everyday activity, "critical" narratives are consequential to actions and to learning in particular (Sfard & Prusak, 2005). When a critical narrative is changed, it changes the person and his or her practice. The challenge for using this approach with novice teachers is that their critical narratives are in flux as they transition across learning-to-teach contexts. Rather than tracing influential narratives as unified stories, it is more productive to trace specific threads of discourses within changing narratives. We assume critical pedagogical discourses become recognizable to others as teachers discuss their practice and interact with young learners. Thus, critical pedagogical discourses are manifested as consistent patterns of participant talk in which the roles, identities, and responsibilities of actors (e.g., self and other teachers, students, administrators, etc.) in the educational setting are conceptualized and negotiated within frameworks of loosely articulated theories about "what counts" as knowing, learning, and effective teaching. Critical pedagogical discourses incorporate one's lived experience and sets of discourses appropriated from multiple socially constructed spaces (Holland, Skinner, Lachicotte, & Cain, 1998). They are shaped by interactions with others and by socially constructed meanings (see contextual discourses) prevalent in a particular institutional context. Critical pedagogical discourses organize and influence one's perceptions of the past and the future in terms of perceiving problems and opportunities, approaches to problem solving, and other choices made in instructional contexts (Bourdieu, 1990). Despite these influences, critical pedagogical discourses are not necessarily consistent with teaching choices, but reflect what individuals believe "should have been done" even if they cannot or will not translate these discourses into action. As such, critical pedagogical discourses are capable of creating significant tensions for teachers.

Contextual discourses, on the other hand, are perceptions of messages about teaching and learning communicated by actors in social situations and institutional environments or through policy statements (Holland et al., 1998; Spillane & Miele, 2007). For example, in the university coursework context, teachers we worked with were exposed to ideas about authentic scientific practices—in particular scientific modeling and how this could support student talk about evidence and explanation. In contrast, during the first year of teaching, several participants were exposed to competing and instructionally conservative discourses from principals, mentors, and occasionally peers about the importance of using "The Scientific Method" with students as a proxy for authentic disciplinary lab work. While such contextual discourses are socially constructed, they are contrived interpretations of one's imagined context (Holland et al., 1998). Though early career teachers are exposed to many contextual discourses, they

resonate with or acquiesce to some but not all messages. Messages that resonate with their developing theories of teaching and learning may become internalized as critical pedagogical discourses and in turn influence pedagogical decisions.

Communities that reinforce different messages about teaching and learning also value particular forms of conceptual and practical tools, such as socially constructed routines, semiotic systems, or material technologies, that mediate the collective intellectual work that defines professional practice (Engeström, 2004; Nasir & Hand, 2006). Recently scholars have identified the importance of conceptual and practical tools in supporting teacher learning (Anagnostopoulos et al., 2007; Grossman et al., 2009), but there is little empirical evidence explaining how these tools influence self-narratives, pedagogical visions, and practice across learning-to-teach contexts.

Contextual Discourses: Ambitious Science Teaching and Supportive Tools and Routines

Ambitious teaching practices formed the basis for our university coursework and university-based induction experience, supplemented by tools and socio-professional routines developed as part of the coursework and induction experiences. Our intention here is to describe the ambitious practices and reifications of these practices (tools and routines) as significant elements of the contextual discourses available to novice teachers (in the form of messages, norms, collectively held values) as they developed critical pedagogical discourses about their evolving role in the classroom.

Ambitious teaching practices focus on supporting student learning across ethnic, racial, class, and gender categories; fostering deep understanding of ideas and engagement in solving complex problems rather than the typical emphases on activities and procedural talk (Lampert & Graziani, 2009; Newmann & Associates, 1996). This instruction requires attention to students' emerging ideas and regular adjustments to practice based on assessment of students' understanding. We focused on a core set of four practices, described in the following, that are generalizable across science teaching contexts and customizable for a variety of subject matter purposes (Duschl, Schweingruber, & Shouse, 2007; National Research Council, 2005; Romberg, Carpenter, & Dremock, 2005).

Selecting Big Ideas/Models

This planning practice helps teachers design learning experiences focused on a limited number of important ideas in the domain. Big ideas are framed by overarching essential questions about the subject matter, giving coherence and purpose to subsequent instructional activities. During the methods course, novices were provided with a conceptual tool for exploring big ideas through a form of model-based inquiry (MBI). They studied

various types of scientific models and how to use them to frame activity for students in science classrooms (see Windschitl et al., 2008). Participants worked with these organizing ideas as they designed scientific investigations and lessons.

Working on Students' Ideas

In this practice, the teacher initiates instruction by eliciting and making visible students' conceptions of the topic of study and uses these initial ideas to inform instructional decisions. Subsequent lines of classroom inquiry emerge from students' partial understandings about an aspect of the natural world. The teacher encourages meaning-making by connecting scientific phenomena to students' lived experiences and knowledge and by engaging students in sense-making discourse about how the activities link to their developing scientific ideas. The teacher assesses development of students' ideas regularly through informal and formal means to provide feedback to students about their current thinking and to make decisions about upcoming instruction (Coffey, Hammer, Levin, & Grant, 2011). During the methods course, we provided novice teachers with a tool that outlined a routine for eliciting students' initial ideas.

Working With Science Ideas

In this practice, science is understood as a developing set of ideas that are built through conversations about activities and content. Novice teachers are supported in developing activities that help students understand science not as a set of facts, but rather as testable models or theories that are revised over time based on evidence and new ideas (Smith, Maclin, Houghton, & Hennessey, 2000; Windschitl & Thompson, 2006).

Pressing for Explanation

Integral to science teaching, the teacher routinely presses for explanations of how and why scientific phenomena occur. The teacher makes explicit how the class's explanations are evolving and the degree to which evidence supports their current models. We designed a tool that specified a routine for investigating students' as well as teachers' scientific explanations. This "Explanation Tool" distinguishes three types of scientific explanations—*what* happened in a science activity, *how* something happened, and a causal explanation for *why* something happened (Windschitl, Thompson, Braaten, & Stroupe, 2012). Novice teachers used this framework to examine samples of student work and to interrogate their own understanding of the science content.

We have some indication that novice teachers are able to develop a shared language about ambitious practices through the use of tools and engagement in an induction community with collaborative cycles of inquiry

into students' work (Windschitl, Thompson, & Braaten, 2011). We found that our induction setting afforded opportunities for novice teachers to test out the language of ambitious forms of teaching, but not all teachers participated in conversations about the analysis of student work in the same way. These observations suggest that it is possible in an induction community setting to build relevant contextual discourses and that discourses from schools do not necessarily overwhelm ambitious practices learned in these settings (Zeichner & Tabachnick, 1981). It remains unclear, however, why teachers from the same program developed different approaches to teaching and reflection on students' learning when straddling worlds of induction and public schools. Given the complexity of this question and its inherent multicontextual focus, we develop a comprehensive and longitudinal method to investigate novice teachers' critical pedagogical discourses.

Method

Using a longitudinal approach, we examined the development of teachers' discourses and practices with a multicase, multisite design (Creswell, 2007; Merriam, 1988) and ethnographic methods to construct thematic narratives (Clandinin & Connelly, 2000) from field notes, artifacts, and participants' commentary.

Participants and Context

We followed 26 novice teachers from two cohorts of a graduate teacher education program at a public university in the northwestern United States. Of the first cohort of 15 students, 11 taught locally and were tracked; of the second cohort, 15 of the 17 taught locally and were tracked. Participants entered the program with undergraduate degrees in either an area of science or engineering (Table 1).

We followed each cohort of participants across learning-to-teach contexts over a 3-year period. The first context was university coursework, which included a 6-month methods course. Ambitious practices were modeled by the course instructor; teacher candidates were supported in preparing, executing, and reflecting on three lessons that focused on eliciting students' ideas, supporting sense-making during material activity, and pressing for evidence-based explanations (for details, see Windschitl et al., 2008). The second context was local secondary schools where participants joined a cooperating teacher (CT) and completed a 10-week teaching practicum. Two of the CTs had graduated from the university program (Marta and Carrie's CTs) and were using many of the ambitious practices. Others varied in the degree to which they engaged students, but generally enacted standard forms of practice. There were no official university program requirements that participants use the ambitious practices; instead, they and CTs negotiated instruction together. However, the first and third authors

Table 1

Participants' Background, Teaching Assignments, and Reported Contextual Constraints in School Contexts, in Order of Use of Ambitious Practices

	Participant	Undergraduate Major (*N* credits in science)	Science GPA	Practicum Context	Practicum Self-Reported Contextual Constraints	First Year of Teaching Context	First-Year Self-Reported Contextual Constraints
Integrated Trajectory	Marta	Biology (88)	3.71	Underresourced high school (HS)	NA	Underresourced middle school (MS) Seventh-grade general science	Lack of school colleagues to discuss ambitious practices
	Simon	Earth sciences (76)	2.62	Underresourced urban MS General science	Cooperative teacher's (CT's) standard practice	Urban MS General science	Lack of school colleagues to discuss ambitious practices
	Rachel	Cell biology (75)	2.67	Suburban HS Physical science and physiology	CT's standard practice	Affluent suburban HS Biology, Physiology	Department's standard practice
	Amber	Biology (97)	3.45	Underresourced urban MS General science	CT's inflexible, conservative practice	Underresourced urban HS Biology	School's limited resources
	Susan	Forestry and earth sciences (121)	3.36	Urban MS General science	CT's inflexible, conservative practice	Underresourced urban HS Biology	School's limited resources
	Imee	Physiology (63)	3.68	Suburban MS General science	CT's standard practice	Urban HS Physical science	Department's standard practice
	Sarah	Chemistry (71)	3.69	Urban MS General science	CT's standard practice	Underresourced urban HS Biology, chemistry, physiology	School mandates
	Barbara	Biology (78)	3.36	Suburban junior high school (JHS) Physical science	CT's standard practice	Suburban JHS Life science	Department's standard practice
	Leslie	Zoology (63)	4.00	Suburban MS General science	CT's standard practice	Affluent suburban HS Biology, chemistry	Department's standard practice and school mandates
	Carrie	Physiology (94)	3.40	Urban HS Biology	NA	Underresourced MS Seventh-grade general science	NA
	Katie	Biology (82)	3.14	Suburban MS General science	CT's standard practice	Suburban MS Seventh-grade general science	Department's standard practice

(continued)

Table 1 **(continued)**

	Participant	Undergraduate Major (*N* credits in science)	Science GPA	Practicum Context	Practicum Self-Reported Contextual Constraints	First Year of Teaching Context	First-Year Self-Reported Contextual Constraints
Compartmentalized Trajectory	Robert	Physiology (76)	2.94	Suburban HS Biology	CT's standard practice	Private HS Biology	Lack of school colleagues to discuss ambitious practices
	Benjie	Environmental sciences (117)	3.09	Underresourced urban MS General science	NA	Suburban MS (long-term substitute) General science	Department's standard practice
	Catherine	Biology (95)	2.75	Suburban HS Biology	CT's standard practice	Affluent HS Biology	District's mandated curriculum
	Elena	Zoology (88)	3.48	Suburban MS General science	CT's standard practice	Suburban HS Physical science, biology, chemistry	Department's standard practice
	Emily	Biology (96)	3.70	Suburban MS Life science	CT's standard practice	Suburban JHS General science	District's mandated curriculum
	Laura	Biology (72)	3.41	Underresourced urban MS General science	CT's standard practice	Suburban MS Eighth-grade general science	District's mandated curriculum
	Amanda	Chemistry (73)	3.23	Suburban HS Chemistry	CT's inflexible, conservative practice	Underresourced urban HS Chemistry	School's limited resources
Nominal Trajectory	Luke	Physics (77)	3.69	Suburban HS Physics	NA	Same school and subject as practicum	NA
	Kelly	Biology (80)	3.26	Affluent suburban HS Biology	CT's standard practice	Urban HS Biology	Department's standard practice
	Patricia	Engineering (47)	3.21	Suburban JHS Eighth-grade general science	CT's standard practice	Suburban JHS General and physical science	Department's standard practice
	Adam	Biology (91)	3.07	Suburban MS General science	CT's standard practice	Affluent suburban HS Biology	Department's standard practice
	Richard	Biology (67)	2.87	Underresourced urban HS Biology	CT's standard practice	Affluent suburban MS General science	Department's standard practice
	Maria	Economics & Biology (62)	3.20	Suburban HS Biology	CT's standard practice	Underresourced MS Sixth-grade general science	Department's standard practice
	Chris	Biology (79)	3.33	Suburban HS Biology	CT's standard practice	Rural HS Physical science, biology	Department's standard practice
	Mike	Technology (77)	3.86	Urban HS Physical science	CT's standard practice	Affluent suburban HS Biology	Department's standard practice District's mandated curriculum

observed lessons and debriefed with novice teachers during practicum that created a press for ambitious teaching. The third context was local public schools during participants' first year as full-time science teachers. Novice teachers joined departments with colleagues enacting fairly standard forms of science teaching. The fourth context was the university-based induction experience that coincided with participants' first year of teaching. During this time, we provided three collaborative work sessions in which novice teachers analyzed pupils' work to identify patterns of student learning (Windschitl et al., 2011). This work, along with continued individual coaching, created a press for ambitious teaching.

Data Collection

Primary data sources included 199 classroom observations and debriefing interviews and a total of 104 formal interviews with 26 novice science teachers. We observed each participant at least 5 times during their practicum and their first year of teaching (average of 7 observations/teacher), recorded detailed field notes capturing the interactions between teachers and students during classroom instruction, and noted features of the classroom and curricular context (Clandinin & Connelly, 2000). We chose windows of 2 to 3 weeks for observations and asked participants to select days within the window when students were discussing "evidence-based explanations following a science activity or laboratory investigation." This purposeful selection contained opportunities for teachers and students to engage in productive conversations and opportunities to document the use of reform-based types of instruction (Kane & Staiger, 2012).

We recorded classroom conversations, paying particular attention to how teachers framed discussion tasks for students and how teachers drew attention to models, explanations, evidence, and observable and unobservable data (typically 10 pages of typed, single-spaced dialogue per observation). We recorded whole class conversations, sampled small group conversations, recorded notes teachers wrote on the board, collected copies of handouts, and took photographs of student posters. Following each observed lesson, we conducted interviews that asked participants to describe instructional aims, how their students were reasoning with science ideas, and successes and missed instructional opportunities during the lesson. We then offered suggestions that related to the ambitious practices and asked participants to comment on our coaching suggestions.

We conducted four formal interviews with each participant, each lasting approximately 90 minutes. Each interview began with open-ended questions, and more targeted questions about practices and tools were used later in the interview (Rubin & Rubin, 1995). All interviews were audiotaped and transcribed in full. The first two interviews were conducted prior to and following university coursework. Questions were designed to elicit informal

theories about effective teaching and conceptions of authentic investigative science. A third, formal interview was conducted after practicum, asking participants to reflect on their instructional experiences during the practicum and experiences in particular school settings. Participants were interviewed a fourth time at the end of their first year of teaching. Here they reflected on changes in curricular visions and teaching practices, described details of their experiences working within specific school contexts, and commented on their experiences working with colleagues within the induction supports. At this point, nearly 3 years into our relationship, we began to develop thematic narratives for each participant (Clandinin & Connelly, 2000) and conducted member checks (Merriam, 1998) about our portrayals of their evolving critical pedagogical discourses and repertoires of practice.

Data Analysis

To address the research questions, we first characterized observed differences among the lessons taught by novices. This allowed us to see patterns emerging within each participant's practice. We then used observation and interview data to develop cases for each participant and conduct cross-case comparisons (Merriam, 1998; Stake, 1995). It was this second analysis that led to the identification of three different learning trajectories for novice teachers.

Coding of Ambitious Practices

We coded classroom observations for instances of four dimensions of ambitious teaching practices across time. We used studies of expert science teaching and expert-novice observational studies in secondary science classrooms (Baldi, Jin, Skemer, Green, & Herget, 2007; Roth & Garnier, 2007) to characterize levels of sophistication for each of the practices. The first 25 observations were coded by two researchers; we reviewed one another's codes and discussed discrepancies. We evaluated lessons based on observed classroom discourse, not teacher self-reports of their intentions for the lesson. Each lesson received a rating for each of the four practices; ratings were based on the most frequent practice observed—if 50% or more of talk in a lesson was at a higher level, then we coded the lesson at the higher level.

Selecting big ideas/models. Three levels of sophistication were identified. From most to least sophisticated were: theory focused, process focused, and topic focused. For example, one participant who used a theory focus for a curriculum unit on ocean's tides framed the phenomenon in terms of gravitational relationships between the earth, moon, and sun. A process focus would examine associations among tides and moon phases, not framed by explanatory theories. A topic-centered focus would be definitions of high and low tide, frequency of occurrence, and locations (Roth et al., 2011; Windschitl & Thompson, 2006).

Working on students' ideas. The three levels of this practice, ranging from most to least sophistication were: eliciting ideas and adapting instruction based on the ideas; eliciting students' initial understandings, but with no adaptive follow-up; no eliciting of ideas, rather an ongoing monitoring, checking, and reteaching for "correct" answers (Coffey et al., 2011).

Working with science ideas. We coded four levels of "working with science ideas," from most to least sophisticated: an epistemic fluency/model-based inquiry focus, forwarding science ideas to work on, discovering/confirming science ideas, and a focus on experimental method. We found that standard science inquiries from participants' curricula underemphasized the testable, revisable, and conjectural nature of scientific knowledge. Instead, their curricula directed students only to confirm or "discover" a known scientific idea (Hammer & Schifter, 2001; Roth & Garnier, 2007).

Pressing students for evidence-based explanations. This dimension represents the degree to which participants focused pupils on underlying causes of events and processes (why explanations), rather than seeking only patterns and trends in data or differences between groups (how explanations), or offering detailed descriptions of phenomena (what explanations). Other studies describe similar levels of sophistication in classroom talk about mechanistic explanations (Hammer & Schifter, 2001).

Coding and Analyzing How and Why Novice Teachers Used Ambitious Practices

With interview data, we identified underlying factors that influenced teachers' reasoning with these practices over time. To address the first research question regarding the appropriation of critical pedagogical discourses and practices, we used ATLASti to code how participants talked about each of the four ambitious practices and ideas from the categories adapted from the Hammerness et al. (2005) framework (critical pedagogical discourses, contextual discourses, tools used, visions of practice in the future). While analyzing interviews, we developed additional codes particular to each individual (Clandinin & Connelly, 2000; Merriam, 1998) to identify and trace the evolution of critical pedagogical and contextual discourses across time. For each participant, we then created interim texts from interview and observation data (Miles & Huberman, 1994).

Themes with the richest descriptions across data sources were used for pattern clarification and cross-case analysis (Miles & Huberman, 1994). We identified types, or families of cases, and described three patterns of appropriation: *integrating multiple ambitious practices, compartmentalizing an ambitious practice*, and *appropriating talk without practice*. For the first type of appropriation, instruction was marked by the use of multiple ambitious practices simultaneously and throughout the lesson. In interviews, novice teachers described how multiple ambitious practices could be

coordinated to support student thinking. The second pattern—compartmentalizing ambitious practices within standard curriculum—was marked by discrete episodes in which teachers enacted one of the ambitious practices, but isolated from other elements of practice. For example, following traditional laboratory activities these teachers tacked on additional discussion questions to press for deeper level of explanations. In interviews, participants would only describe pedagogical visions around a single ambitious practice. In the third pattern, teachers nominally appropriated talk without practice. During instruction, for example, they used "explanation" language and scientific models, but in superficial ways and without actual adaptations to the standard curriculum. This language was also apparent in reflective talk about the lessons.

To address the second research question of how tools and routines for ambitious practice supported teacher learning, we examined the frequency of tool use, the contexts under which tools were used, and teachers' descriptions of how they used tools across contexts. For instance, taking the name of a particular tool as a code, we revisited interviews and classroom observations to track the connections between a particular tool and participants' pedagogical reasoning. This analysis allowed us to draw conclusions about how participants used tools and associated social, collegial routines of conversation to refine a beginning repertoire of practice.

Findings

We begin by summarizing three distinct patterns of development, characterizing the ways in which participants negotiated tensions imposed by different contextual discourses and the ways in which tools were used as levers for pedagogical experimentation. One group of novice teachers appropriated ambitious practices from the teacher education context and during their practicum and readily integrated these practices into their everyday curriculum. They used tools to imagine what practices might be possible in their classrooms and shared these in the induction community. A second group of teachers gradually created "compartments," or specific times and places within their standard curriculum, where they imported a single ambitious practice. Rather than use the tools firsthand, they borrowed routines they had seen peers create with the tools to create visions of idealized practices. A third group of teachers nominally appropriated language from the university and induction contexts, but used the language only to label what they were currently doing. They did not use the tools or take up ambitious practices.

Figure 1 shows how observed classroom practices mapped onto these three patterns. Looking at the dark shading in Figure 1, we see that approximately one-third of the first-year teachers were at the more sophisticated ends of the spectra (integrated group). The range of classroom observations seen had roughly a "normal" distribution. However, the individuals on the

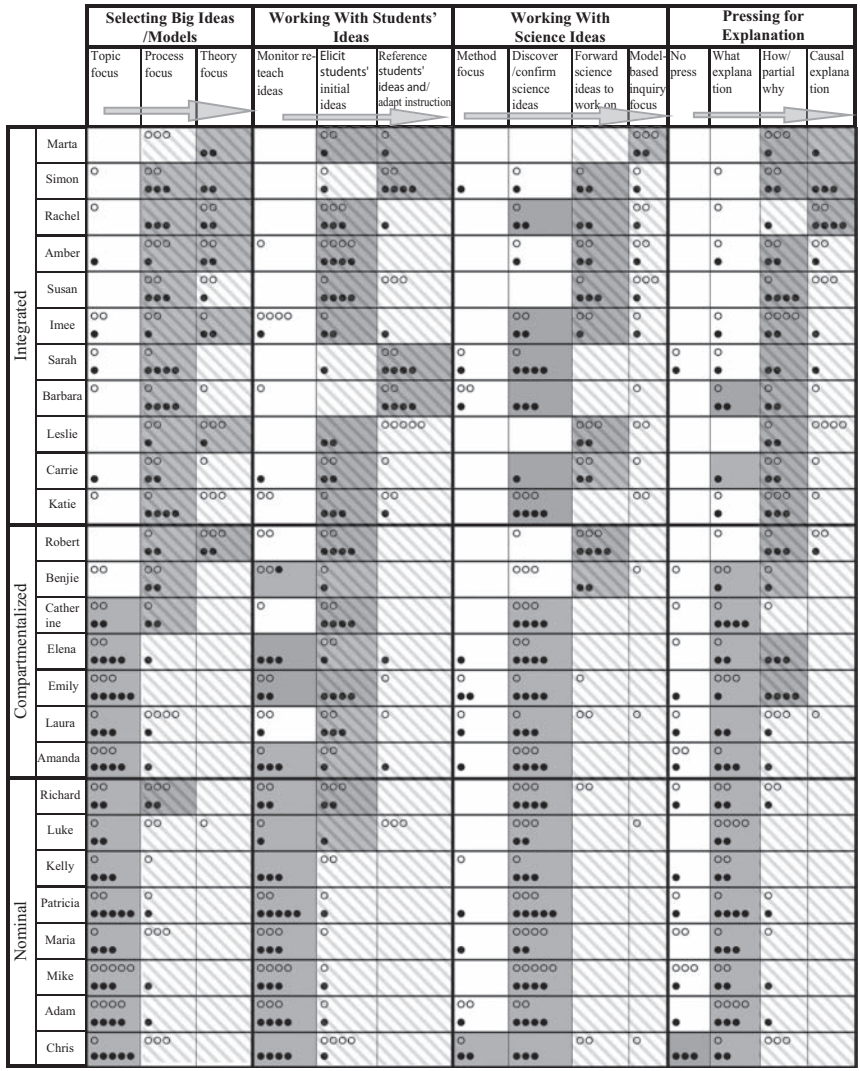

Figure 1. **Observed implementation ambitious practices during practicum and the first year of teaching.**

Note. The range of sophistication for each practice is listed across the top, and the crosshatched columns represent ambitious forms of teaching that go beyond what the participants' standard curricula required (i.e., design of classroom tasks, questioning, activities). The columns that are not crosshatched are characteristic of traditional forms of teaching or typical of school curricula requirements. Each dot represents the most sophisticated practice we noted in each observation of teachers during their practicum (open dot) and first year of teaching (black dot). The dark shading indicates the teachers' prevalent (most frequently observed) pattern of practice during their first year of teaching.

sophisticated end of this spectrum were engaging in teaching practices that, although clumsy in their implementation, are rare even for experienced professionals (Alexander, Osborn, & Phillips, 2000; Banilower, Smith, Weiss, & Pasley, 2006). In a review of novice educator practice, Hogan, Rabinowitz, and Craven (2003) wrote that "the implementation of strategic approaches to questioning, and the elicitation of student understandings remained virtually absent from their dialogue in class" (p. 243), yet at least 15 of the novice teachers in this study attempted the practice of not only eliciting students' ideas, but significantly adapting instruction to build on these ideas. What is not shown in Figure 1 are the ways in which the three trajectories were informed by how the practices were situated within lessons and how teachers described their practices in relation to standard curriculum in the interviews. This is why, for example, we distinguished between the groups despite some similarities in their classroom practice profiles.

We first tested more commonplace explanations for these differences in practice, involving participants' content knowledge, the quality of mentoring, and the degree to which individuals felt pressured to teach a mandated curriculum. Table 1, organized by the three trajectories, shows no clear examples of how any of these factors alone might have played a part in teachers' beginning practices. The data about subject matter understanding are mixed. For example, of those who did not appropriate multiple forms of ambitious teaching, some had strong science content knowledge and others did not. There appears to be no strong association between undergraduate science GPA and the approximation of sophisticated forms of practice. There does seem to be a lower threshold, however, particularly for novice teachers not holding an undergraduate degree in science. They more uniformly struggled to enact reform practices. Regarding mentoring, of those who took up sophisticated practices, only two (Marta and Carrie) had strong, supportive mentors during their internships; their cooperating teachers were graduates of the same university program and used ambitious practices. Most teachers in each group, on the other hand, reported feeling pressured by mentors and colleagues in school settings to conform to traditional forms of teaching. The lack of definitive associations here suggests that interactions with mentors and colleagues were not sufficient to account for patterns of appropriation.

To explain variation in these beginning teacher repertoires, we turn next to descriptions of the trajectories and how teachers identified with different communities and appropriated language (Research Question 1) and tools in these communities (Research Question 2).

Trajectory 1: Integrating Ambitious Practices

Eleven of the 26 novice teachers successfully integrated multiple forms of ambitious practices (Marta to Katie, Figure 1). Nine of these 11 did so regardless of their school teaching context or the type of science subject

matter they taught. Susan and Leslie are exceptions, who during their first year of teaching attempted less ambitious practices than during practicum. This group's initial appropriation of ideas underlying ambitious practices occurred early (in university teaching methods course or during practicum), and their experimentation with ambitious practices was also early (the beginning of practicum). All members of this group tried multiple ambitious practices simultaneously and in coordination with one another in the classroom. For example, it was not uncommon to see their students revising a model of a science phenomenon and comparing differences in their explanations. These student-to-student conversations were guided by the teacher prompting students to provide gapless explanations from their partial responses.

Teachers in this category were distinguished by the fact that they modified existing conceptual frames for teaching based on student-thinking frames promoted in the teacher education context. Similarly, they gravitated toward instructional practices that revealed and then "worked on" student understandings. They readily integrated the vision, language, and tools from the university coursework and induction into their teaching repertoire. Sarah's story illustrates why identification with ambitious practices occurred early, why participants like her were able to use tools as the basis for pedagogical innovation, and why these teachers were able to sustain these practices during the first year of teaching. We selected Sarah because, like others in this group, she modified her initial ideas about teaching and learning during the science methods course and because during practicum she did not initially show sophisticated use of ambitious practices despite incorporating all four of the ambitious practices into her developing curricular vision.

In her first year of teaching, Sarah worked at an impoverished and ethnically diverse high school. Over time, she adopted two powerful threads to her critical pedagogical discourses: (a) an interest in what students think and (b) a focus on how students learn. These threads emerged in the teacher education program and continued to develop during practicum. While Sarah's initial attempts at practices around model-based inquiry and pressing for explanation were relatively superficial, they represented modestly more sophisticated instruction than prescribed by standard curricula. For example, during practicum she moved beyond her school's curriculum by prompting students to consider scientifically rich explanations, challenge one another's ideas in small group, and use evidence to connect multiple lines of scientific reasoning. When faced with instructionally conservative contextual discourses from her school and district, she either chose to ignore or reshape these messages to fit with her ideas about placing student thinking at the center of her practice.

The Interaction of Critical Pedagogical and Contextual Discourses

Participants like Sarah readily appropriated and integrated multiple ambitious practices in part because they developed strong commitments

to "working on student thinking." This stance aligned with conceptual frameworks, practices, and routines described in the university coursework context and was further supported by tools and routines in the induction context. Participants' critical pedagogical discourses were not verbatim replications of the conceptual frameworks promoted in the coursework and induction. Rather, each participant in this trajectory generated a unique perspective on why it was important to attend to students' ideas: Rachel, for example, framed her focus on student thinking as a way to mirror the work of scientists, Simon replaced his generic talk about teaching for social justice with talk of pressing *all* his students to think deeply about science ideas, and Barbara referred to student and teacher questions as a way for students to uncover and work on their own ideas.

For Sarah, her critical pedagogical discourses involving a genuine curiosity for what students think and how students learn guided most of her pedagogical decision making. Ideas from university coursework and induction context about focusing on student thinking and pressing for scientific explanation were adopted as her own:

> I think it's really important to get students to start thinking about what they know [or] what they think they know . . . and providing opportunities for them to be puzzled or to question what's going on, and to have to really try to come up with an explanation instead of just me telling them . . . talking to each other more and trying to work together to figure things out. (Post–first-year teaching interview)

Sarah tried to create learning experiences that fit "how students learn." In practice, this meant that she regularly chose to elicit and build on students' ideas, weave students' ideas together with science ideas during sense-making discussions, encourage students to draw representations of their ideas and explanations, and push students to connect lines of evidence and reasoning together. She found students' ideas illuminating and regularly created tasks that revealed student thinking. She also began to value having students connect big scientific ideas as a way for them to reflect on their thinking:

> I'm looking for more evidence of thinking. But also evidence that—like for students to be creating explanations and thinking about explanations—they're really putting things together from different activities and different units. (Post–first-year teaching interview)

The integrated group experimented early with standard curricula as a way of working toward a curricular vision shaped by their emerging student-thinking critical pedagogical discourses. At the beginning of Sarah's practicum, there were attempts at the practices that later became typical of her beginning repertoire. For example, while teaching middle school physical science, Sarah engaged students in the construction of a concept

map over the course of a unit on physical and chemical changes. She prompted the students to include experiences from their everyday life (e.g., toasting marshmallows) and recollections about lab activities they had done in class. By the end of the unit, Sarah and her students had created a detailed representation of their collective thinking about the differences between physical and chemical changes. Sarah, however, remained dissatisfied with the unit: "I liked that it had groups talking about ideas and then also using a visual representation of their ideas . . . but, I think it would have been helpful if we connected to the bigger concept" (Post–student teaching interview). Experiences like these helped her see her vision-to-practice gaps and, importantly, identify concrete steps to close these gaps in future instruction.

The integrated group also used their developing critical pedagogical discourses to "filter" the influence of standard curriculum and explicit requests by colleagues in schools to conform to more conservative practices. In one case, Sarah was asked by her principal to set aside class time for literacy coaching strategies. Rather than setting aside time as her colleagues were, she instead recontextualized the practice in combination with science activity to support students in constructing rich explanations. For Sarah, other conservative contextual discourses that could not be reconciled with critical pedagogical discourses were tabled—especially if they did not help Sarah teach in ways that fit with "how students learn":

> Well, whatever our district's plan for our pacing guide and things like that, the curriculum . . . I tried to make it all fit and stay on track with everyone [other department members], but I started falling behind because they were like, "Okay, we're done. We're moving on" and I was not . . . I wanted to do more discussions and different assessments—not just tests. (Post–first-year teaching interview)

Overall, this group of novice teachers did not initially have well-articulated theories of teaching and learning when they entered the university program, yet most had initial threads of critical pedagogical discourses that aligned with frameworks taught in the science teaching methods course. In classrooms, they gradually experimented with practices that would fit with their internalized student-thinking critical pedagogical discourses. This early development of critical pedagogical discourses and a growing repertoire of pedagogically coherent practices helped buffer against conservative contextual discourses during practicum and in their first year of teaching.

Using Tools and Routines to Address Vision-to-Practice Gaps

The integrated group was notable for the ways they used tools from the university coursework and induction contexts, not only to support their current practice, but also to spark their pedagogical imagination. As curricular visions evolved, they attempted to translate these visions into innovative

practice. Some of these experimental attempts, over time, became valued routines. Sarah adopted tool-based instructional practices for pressing for scientific explanation, supporting student-generated models, and eliciting students' thinking. She also went beyond the practices originally associated with our tools, in particular the "what-how-why" Explanation Tool. For example, during her first year of teaching she created a concept mapping activity to help students link evolution and genetics. Students were asked to construct two maps of their ideas from different units of instruction—natural selection taught at the beginning of the school year and genetic variation from the end of the school year. Sarah asked them to use these representations to explain why sickle cell anemia persists in populations over time. Students generated a bank of ideas that could be included in each map, and then pairs of students worked together to create maps connecting the ideas. Sarah then asked students to make connections between the two concept maps by pressing students to consider how aspects of genetic variation were related to aspects of natural selection. In small group classroom conversations, she probed for "why-level" explanations and did not relent on her line of questioning until students reciprocated this level of engagement. These practices—scaffolding written and spoken explanations by using sentence stems, offering tools for students to map ideas, encouraging graphic organizers for articulating bodies of evidence, and helping students move beyond surface-level explanations—were all innovations on her part. She describes how tools such as the what-how-why explanation rubric helped her maintain her focus on student thinking and learning:

> If I didn't [participate in induction] I probably wouldn't have spent time really looking at student learning. Using the rubric [Explanation Tool], looking at evidence, looking at the big idea helped me think about how I should be looking for levels of learning and assessing how well they're learning the concept and how well I'm teaching it . . . I was trying to plan an assessment for my genetics unit and that made me really think, like, what would you have to know in order to be an expert thinker about genetics. (Post–first-year teaching interview)

For Sarah, the Explanation Tool helped her focus her pedagogical vision and refine her critical pedagogical discourses by adding increasingly well-defined practices to support student learning. Sarah's critical pedagogical discourse about how students learn and think began as a vague learning theory following university coursework. This theory became coherent in concrete practices such as eliciting and building on students' ideas, weaving students' ideas with science ideas during sense-making discussions, using graphical representations to help students construct scientific explanations, and connecting lines of evidence together to support student thinking about big science ideas.

Trajectory 2: Compartmentalized Practice

While the integrated groups' 3-year story can be summarized as the coevolution of ambitious practices and curricular visions, the story for the compartmentalized group of teachers was about the development of "borrowed" visions kept within a conceptual box. Seven of the 26 novice teachers in this study (Robert to Amanda, Figure 1) selected a single ambitious practice to work on within a pedagogical "compartment," meaning they experimented with the practice in conceptual isolation from other practices. They tended to appropriate *ideas* for such practices from the induction community, but translating them to classroom activity took considerable time. The drawn-out fashion of their learning was due in part to their attempts to reconcile their own vague, gestalt-like critical pedagogical discourses (e.g., invoking sweeping statements such as "students need ownership of ideas" and "students should do inquiry") with the borrowed practices. The schools where these teachers worked, like all of the participants' school settings, asserted clear institutional agendas for covering content and keeping pace with colleagues. Participants whose appropriation of practices followed the compartmentalized trajectory borrowed these messages and associated practices in addition to ideas and practices from the university settings. Participants' gestalt-like critical pedagogical discourses could not serve a filtering function as it did with the integrated practices group; instead, this second group of participants held ideas and practices emerging from different communities in separate compartments and worked slowly to reconcile those boundaries.

We feature Emily's story to describe why only individual ambitious practices were appropriated and why learning from and about these practices took significant time. Emily taught eighth-grade science at a junior high school. During her first year, she gradually shifted from teaching rote procedures associated with the scientific method toward pressing for evidence-based explanations of scientific phenomena, within a school context that expected the curriculum to be taught "as is." Emily focused on the "use of evidence to support explanations" as one pedagogical compartment during her first year. For most of her first year, this ambitious practice was only partially taken up in the classroom. However, her participation in the induction context helped her clarify more sophisticated visions of this practice, and by the last week of her first year of teaching, she had made significant changes to her teaching.

The Interaction of Critical Pedagogical and Contextual Discourses

The slow trajectory of appropriation of a single, isolated ambitious teaching practice by these teachers can be explained in part by the fact that they did not develop ideas about teaching and learning that were directly applicable to practice during the university coursework or the

practicum experience. Without clearly defined critical pedagogical discourses to act as filters, they spent practicum and their first-year teaching trying to refine beginning repertoires while weighing contextual discourses that pulled their practice in different directions.

These participants had teaching-focused—as opposed to student thinking–focused—critical pedagogical discourses. These were evident in broad gestalt-like statements about their vision of the ideal science teacher or classroom environment. These discourses were too vague and unspecified to generate principles for selecting some teaching practices over others or for developing a set of routines. For example, by the end of university coursework, Emily had developed a vision that "students need ownership of their investigations and data; they need to discover knowledge for themselves." Linked to this weakly defined sense of ownership were desires for curricular relevance: "I need to make science real and empower students to be critical thinkers and consumers." This vision of herself as someone who encourages learning was partly defined by the kind of teacher she did not want to be: "I probably didn't think a lot about this before starting teaching, but building a community in the classroom that can work cohesively together. That's a really big idea to get students to work in groups and not to be a straight-out lecturer" (post student teaching). Emily did not mention specific practices associated with these sweeping statements.

Coexisting with these vague critical pedagogical discourses were highly specific discourses about science procedures, which were at epistemological odds with the ideas of sense-making and model-based inquiry taught in the preparation program. These procedural discourses were too narrowly defined to help recontextualize instructional practices taught in the methods course for use in classrooms. For Emily, her "doing science" discourse revolved around the teaching of the scientific method as an organizing framework for writing about science. In addition to organizing lab reports, each week students were asked to devise a hypothetical study in which they specified a problem, hypothesis, and variables (about any topic—including ones without any basis in science). While this critical pedagogical discourse had little overlap with practices taught in the methods course, it was consistent with district and state objectives and with institutional messages in her school to focus on science procedures.

Because some threads of their critical pedagogical discourses were too broad and others too narrow, the compartmentalized group was susceptible to contextual discourses that mandated enactment of standard curriculum with specific practices that could be "borrowed" readily. Emily rarely deviated from the school's curriculum and only made minor changes based on time allocations. Only over time was this group able to enact selected, albeit isolated, ambitious practices. This change was linked to their interaction with the tools and routines provided during induction.

Using Tools and Routines to Address Vision-to-Practice Gaps

For this group of teachers, changes to their visions and beginning repertoires of practice were supported by the regular use of tools and routines in the induction context. Because the tools and routines we introduced generally aligned with their gestalt critical pedagogical discourses, they used induction tools and routines to establish borrowed visions of worthwhile teaching practices. Emily, like others in this group, used the induction context to clarify visions of "ideal" lessons—bridging her vision-to-practice gaps. Emily describes how the tool-based routines in the induction context served this function:

> It's taking a situation which we have and making it ideal. Knowing what an ideal situation looks like is great. The CFGs [Critical Friends Group meetings during induction] helped me change what I was doing in the classroom. Knowing what that looks like, or just discussing how to change it and make it better next time with not just my brain but with somebody else's brain and hearing other people's ideas. Highly important . . . I don't think that the growth that I feel like I see and expect out of my students would be where it's at now if I didn't have them [CFGs]. (Post–first-year teaching interview)

More than just borrowing ideas from practices associated with the tools, this group of teachers also borrowed visions of the pedagogical extensions of the tool-based practices from the integrated group of teachers (Trajectory 1). For example, after examining Rachel's student work, Emily tried to apply Rachel's strategy for diagramming observable and unobservable events to support a scientific explanation following classroom investigations. The compartmentalized group used these images of others' practices to refine their visions and language about the ambitious practices. While the teachers in Trajectory 1 were readily appropriating practices from the university contexts and routinely innovating new extensions, teachers in Trajectory 2 were slowly borrowing and working on isolated visions and practices featured by colleagues.

Whereas the integrated group (Trajectory 1) used all the tools and routines to create new visions of possibilities for students, the compartmentalized group adopted practices associated with only one—the Explanation Tool, which was used regularly in induction activities. Two practices associated with this tool were adopted: creating why-level questions for assessments and unpacking a scientific explanation as a way to interrogate their own understanding of science content. It is not surprising that this group gravitated toward tool-based practices for teaching given that their critical pedagogical discourses were framed in terms of teaching procedures. They used the Explanation Tool to create a vision of the questions they should pose to students. Emily explained:

> It [Explanation Tool] told me a lot about what questions I could ask to make sure that students are bringing more into their conclusions. So this rubric was helpful for me to assess what kinds of questions I'm asking and are they helping the student get to a level 3 [an explanation for why something happened] or are they just helping the student get to a level 1 [an explanation for what happened]? (Post–student teaching interview)

Through repeated use of this tool and engaging in induction supports with peers who tried similar practices, these teachers began to shift their instruction to include more why questions in written and oral assessments by the end of their first year. While this group was able to shift toward more sophisticated versions of one dimension of ambitious pedagogy, other dimensions were not "carried along" simultaneously as was the case for the integrated group of teachers (Trajectory 1).

These participants' gradual uptake of practices linked to the Explanation Tool stands in contrast to their reluctance to use other tools/routines. In one case, the teachers were introduced to a conceptual framework for supporting students during model-based inquiry. Without the coupling of concrete practices, using scientific modeling with students remained an unrealized vision.

Overall, the slow evolution of ambitious practices among teachers was matched by a slow evolution of their critical pedagogical discourses. By the end of their first year of teaching, they had begun to adjust their gestalt discourses by folding in language about pressing for explanation drawn from the tools and routines in the induction context. However, the underlying essence of their critical pedagogical discourses—conceptualized as a set of teaching procedures—remained unchanged.

Trajectory 3: Appropriating Language Without Practice

Eight teachers developed a beginning set of practices that were not conceptually based in ambitious practices. Their practices reflected interactions with non–university-based learning-to-teach communities. Over time their classroom teaching practices did evolve—as they refined elements of standard teaching (supported by departmental curriculum, district mandates, and colleagues)—primarily making modifications to the pacing and sequencing of science lessons and developing more convenient routines for checking students' "answers."

In terms of their interactions with ambitious practices, these teachers tended to relabel their existing images of practice with language from the university coursework and induction contexts. In some cases this was done to maintain social affiliations in the induction community and/or possibly to appease the instructors. Such actions, however, failed to produce changes to their emerging repertoires. At best, the teachers with direct

guidance experimented with a few ambitious practices, but these limited attempts during practicum were never replicated. To outsiders it might appear from talking with this group of teachers, or observing their classrooms, that their practice shifted as a result of university coursework and induction and that some regressed to more conservative forms of instruction during their first year of teaching. However, we are not convinced that they ever fully adopted ambitious practices, because their critical pedagogical discourses and curricular visions were not modified to include ideas from the ambitious practices.

The Interaction of Critical Pedagogical and Contextual Discourses

This group of teachers primarily held conceptual change critical pedagogical discourses, meaning that they wanted to help students confront preexisting notions about a scientific phenomenon. Their classroom practice and explanations of these practices were similar to what Resnick (2010) refers to as "stamping-in" right answers and "stamping-out" wrong answers. This stance on teaching and learning was established prior to entering the teacher education program. Participants cited specific, preexisting contextual discourses (e.g., their experiences in science courses) as instrumental in building their vision and practice for science classrooms. However, these preexisting contexts offered simplified images of science teaching and learning that stood in contrast to complex, ambitious science teaching.

Their critical pedagogical discourses shaped how they interacted with practices endorsed in the university context. For example, in classrooms the teachers on this trajectory nominally switched from emphasizing conclusion writing (merely having students restate trends in data) to emphasizing explanations, though their directions to students on how to accomplish this remained virtually unchanged. They emphasized the importance of using scientific models as illustrations of phenomena, but not as ways of acting on one's own thinking. Similarly, they used strategies to elicit students' ideas, but subsequently only triaged "wrong" ideas with reteaching.

While these teachers had conceptual change-oriented critical pedagogical discourses, their commitment to these discourses varied considerably. Some teachers' discourses were dominated by this form of talk, and they had a number of associated established practices. Novice teachers in Trajectory 3, who established conceptual change critical pedagogical discourse prior to the teacher education program, were unaffected by contextual discourses, including ours. For others, their practice was minimally influenced by their weak conceptual change critical pedagogical discourses. Instead, multiple contextual discourses (departmental norms and existing curriculum) dominated their curricular visions. Variations in critical pedagogical discourses had implications for the type of interaction with contextual discourses.

One variation of nominal appropriation. Patricia's story is relatively simple given she did not have robust critical pedagogical discourses and was readily swayed by the contextual discourses promoted in her school communities. Without strong critical pedagogical discourses, teachers who nominally appropriated tools and practices from university coursework and induction were more likely to echo contextual discourses from their school colleagues and use conservative forms of teaching endorsed in their schools. They attributed this to institutional constraints as Patricia alludes to in this exchange:

> Jessica: How much of your teaching decisions are driven by the fact that you are at this school?
>
> Patricia: 75% probably. . . . Well, first off this is what we teach in eighth and ninth grade . . . then there is the expectation that it is fairly clear to me when I was hired that you need to follow the state standards. I think then there is the piece of your colleagues . . . you don't want to be working against the grain. (Post–first-year teaching interview)

When asked this same question, teachers in the integrated category replied that they would be the same teacher regardless of context and that their core commitments could not be altered by the school context. In contrast, the nominal appropriation teachers seemed less committed to their own ideas and more likely to blend in with their department colleagues by adopting their ideas and practices. Similarly, they framed ideas from university coursework as questions that need to be reconciled with curriculum demands. In terms of practice, they typically enacted, without question, curriculum provided by departmental colleagues.

Another variation of nominal appropriation. The teachers in this subgroup justified their sequence of ideas, lessons, and units taught based on preexisting understandings of how science is typically taught. In this quote, Luke—who had experience as a teaching assistant with a group that focused on revealing and correcting students' preconceptions—described his vision of when it is appropriate to use more ambitious forms of pedagogy. He borrowed language about models and why explanations emphasized in university coursework and induction, but layered these on top of his ideas about the right sequence for learning scientific ideas.

> Kinematics is not . . . you're certainly not building a model. You're building a set of rules that will make predictions for you down the line. It's traditionally done that way, and even in the [physics] curriculum which does it to a large extent is the silo idea of kinematics. You're going to understand everything about kinematics, and *then* you describe dynamics—*then* you talk about "why" it happened. We don't talk about "why," you know? That's what's interesting, the "why" is . . . I mean, you want to get to the "why" eventually. (Post–student teaching interview)

Luke was guided by two threads of critical pedagogical discourses drawn from his undergraduate experiences: learning physics as a sequential cumulative process of conceptual change and learning can only be brought about by using research-based, predetermined questions as designed in the curriculum he used as a teaching assistant. Luke's critical pedagogical discourses filtered out most contradictory contextual discourses (primarily from the induction settings in regard to the value of pressing for student explanation and "what counts" as learning), mirroring the type of interaction between critical and contextual discourses for teachers in the integrated trajectory, but preserving instead a conservative approach to instruction. Novice teachers in this variation of Trajectory 3 only appropriated the talk, not the practices promoted by the preparation program. Perhaps not surprisingly, during their first year of teaching many of these teachers distanced themselves from both the ideas and their university peers in the induction context.

Using Tools and Routines to Address Vision-to-Practice Gaps

For this group of teachers, none of the tools used during the science teaching methods course or during induction supported their experimentation with ambitious practices. These teachers did not use the curricular vision supplied by the university and induction contexts to create goals. Not surprisingly, the tools and routines were perceived as superfluous. Many, however, used tools endorsed by the departments, schools, or districts to modify their vision of classroom possibilities. For example, district pacing guides were used readily by participants to alter the sequence of lessons.

Discussion

In the discussion, we address why some novice teachers took up discourses and practices associated with ambitious teaching while others were unable or unwilling to do so. We describe three explanatory features underlying the trajectories observed and then synthesize these features in a revised theory of ambitious early-career teacher practice.

Different Ways of Participating in Professional Communities, Different Trajectories

Novice teachers participating in this study engaged in different types of discourses and practices, leading to different developmental trajectories—integrated appropriation, compartmentalized appropriation, and appropriation of language without practice—as they straddled teaching contexts, one that pressed for ambitious teaching and the other that supported more standard forms of teaching. We do not claim that some teachers' repertoires evolved and others did not. By the end of their first year of teaching all

participants had developed a suite of practices that resulted in discursively oriented classrooms, yet the depth of their students' talk about scientific models and explanations varied. We explain this variation by highlighting three features that defined each trajectory, namely, that: novices differentially affiliated with communities in the university and school contexts, novices developed different types of critical pedagogical discourses across these contexts, and novices selectively used tools and routines that helped them achieve goals valued by the communities with which they affiliated. The discussion is organized around these three explanatory features whereas the findings were organized around the three trajectories. The first two explanatory features address the first research question and the third addresses the second research question.

Explaining Novice Variation, Dimension 1: Affiliation Differences Within and Across Communities

While at first glance the trajectories seem to differ primarily in terms of the type of developing critical pedagogical discourses, what is important is how these discourses influenced and were influenced by membership in university and school communities. *The development of early expertise was dependent on how teachers negotiated membership in and across communities that provided different images of teaching.* Defining one's membership in university communities, school communities, or both required that novice teachers constantly compare and contrast their current curricular visions with what appeared possible in the future. Others have theorized about the development of teachers' learning trajectories based on affiliation with one community, brokering between communities, and moving toward new communities (Jurow, Tracy, Hotchkiss, & Kirshner, 2012; Wenger, 1998) but have not reasoned about how *tensions* among different communities influence novice teachers' language and emerging practice. In our case these communities represented the two-worlds problem. The teachers who integrated ambitious practices (Trajectory 1) primarily affiliated with the people and the ideas associated with the university and induction contexts. They invested in specialized tools and routines promoted by this community, supported others who envisioned teaching similarly, and shared strategies for working through and around the pressures of their own day-to-day conservative teaching contexts. In their school communities they still maintained productive working relationships with teaching partners and principals. The teachers who compartmentalized segments of ambitious practices (Trajectory 2) tried to maintain affiliations (Gee, 2001) with two communities that provided substantially different visions of ideal practices. They did this by replicating others' curricular visions from the induction context, without developing their own actionable, coherent theories about learning and teaching. The teachers who appropriated language but not practice

(Trajectory 3) worked to preserve primary membership in school science departments with more traditional visions of teaching.

The notion of identifying with entire communities (and their prevailing contextual discourses) challenges the notion that novice teachers simply identify with specific individuals whose practice they might value—such as a methods instructor (Nolen et al., 2009) or a cooperating teacher (Rozelle, 2010). Identifying with entire communities may better explain why participants took up a range of practices regardless of their trajectory and how they developed certain ways of talking about problems of teaching and learning over time. Members of the integrated group (Trajectory 1), for example, collectively built on one another's insights during the university-based induction to reframe problems of practice and make innovations in practice a norm within that community—a development that is unlikely to unfold by associating with one other individual, no matter of how skilled. Moreover, this is an example of how the development of critical pedagogical discourses can have a reciprocal effect on contextual discourses—novice teachers did not just participate in established routines in the induction context, they reorganized the activity and talk to serve valued goals (Engeström, 2004). Regardless of the trajectory then, all teachers worked to solidify social and professional affiliations with preferred groups and used contextual discourses associated with these groups to define normative practice. These stories of membership were consequential for developing practice (Sfard & Prusak, 2005).

Explaining Novice Variation, Dimension 2: Development of Critical Pedagogical Discourses Focused on Student Thinking

Observations in this study suggest that it is possible for novice teachers to take up ambitious practices, but this trajectory depends on developing critical pedagogical discourses that prioritize student thinking and are robust enough to reject or redirect contextual pressures to teach in conservative ways. Interestingly, novice teachers in all three trajectories developed critical pedagogical discourses that could be broadly grouped as "focused on student learning." However, only one variation (Trajectory 1) of this critical pedagogical discourse supported the integration of multiple ambitious practices with standard curriculum. This section of the discussion specifically examines how these individuals' views of student learning accelerated both teacher and student learning. Not only were their critical pedagogical discourses focused on eliciting students' ideas, but they also devoted energy to understanding how and under what conditions students' ideas changed over time. This knowledge is more than a consequence of "interest" in student thinking and it encompassed more than a pedagogical stance about supporting students' scientific thinking. To distinguish this type of inquiry into student thinking from more generic "student-centered" or

"learning-centered" conceptions is crucial because this facet of one's critical pedagogical discourses may explain why only some novices develop pedagogical innovations that continue to build their repertoire of ambitious practices. In other words, by developing a critical pedagogical discourse focused on teasing apart students' ways of making sense of science and then engaging in principled experimentation about talk and tasks that could advance these ideas, these novice teachers positioned themselves to accelerate their learning as well as their students' learning. The literature on expertise provides numerous accounts of how discursive classroom environments, aimed at making thinking public, contribute to a cascade effect on both teacher and student learning, thus contributing to the development of classroom communities that treat students' ideas as legitimate resources for building knowledge (Cohen, Raudenbush, & Ball, 2003).

The shaping of novice teachers' critical pedagogical discourses (through affiliation with the university coursework and induction contexts and the appropriation of tools and routines—described later in Dimension 3) helped those on the first trajectory end their first year of teaching with one or two principled statements that guided their instructional experimentation. They formed narratives of being teachers who elicit, listen, and puzzle over how to build on students' tentative understandings of science ideas. The consolidation process of defining their essential roles as an educator helped them override contextual pressures to teach in conservative ways. Their critical pedagogical discourses were "actionable" in focus and coherence, meaning that they guided the selection of everyday teaching practices, accommodated new curricular visions of ambitious practices, and were modifiable enough to support tool-based pedagogical innovations from the induction community.

Novice teachers who compartmentalized or nominally appropriated ambitious practices did refine their critical pedagogical discourses and classroom practices over time, but we did not observe any of these teachers overhauling their critical pedagogical discourses or working with pedagogical tools in new ways that might alter these discourses. There was no evidence, for example, that the compartmentalized group (Trajectory 2) moved any closer to a student-thinking critical pedagogical discourse over time, despite their shifts toward more ambitious classroom practices. It seems that certain ambitious practices can be supported by different types of visions, albeit in a limited way for those on the second trajectory (compartmentalizers).

Both stage theory (Bullough & Baughman, 1997; Feiman-Nemser, 1983) and the expert-novice literatures (see Berliner, 2004) hold that beginners first concentrate attentional resources on their own performance, then later on students. This was not the case in our study. We found that models of universal, sequential, and context-independent teacher development are not tenable. Not all novice teachers, for example, began at the same "starting place" in terms of their critical pedagogical discourses. Moreover, two-thirds

of the novice teachers in this study (Trajectories 2 and 3) developed critical pedagogical discourses that were hybrids of a focus on teacher performance and on student learning. We agree with Levin, Hammer, and Coffey (2009) that beginners are capable of attending to student thinking and that the reason they may not do so is that in shifting contexts from teacher preparation to school settings, they become subject to the constraining ideologies of classroom control and learning as fact acquisition (Kennedy, 1999). Revising discourses around student thinking might not be possible as long as professional work takes place in a culture that conserves the status quo in terms of pedagogy, curriculum, and student expectations.

Explaining Novice Variation, Dimension 3: Tools That Support Revisions to Critical Pedagogical Discourses

To address our second research question, we examined how pedagogical tool systems (Resnick, 2010; Sfard & McClain, 2002) influence teaching. *Taking up well-designed tools supported modifications to discourses and practices and helped novice teachers address vision-to-practice gaps. An important caveat is that, depending on coordination of contextual and critical pedagogical discourses, tools are treated as different types of resources for modifying practice.* Teachers in the compartmentalized and integrated groups used tools for different purposes, both of which supported their learning.

For the compartmentalized group (Trajectory 2), tool-based *routines* shaped the development of ambitious practices. Specifically, only routines associated with the Explanation Tool helped them revise visions and practice. Importantly, this tool contained both specified pedagogical and conceptual components, meaning that it suggested a set of specific teaching routines linked to conceptual ideas about an ambitious practice. For these novices, whose critical pedagogical discourses focused on teaching of procedures, having a tool that offered concrete examples of "the next level" of pedagogy afforded the opportunity to create borrowed, but implementable, visions of practice. These novices were "practice-forward" in their use of tools and routines, meaning that they first experimented with an ambitious practice and later refined a curricular vision around the practice. Their tool-based collaborations with peers during induction were vital to the appropriation of practices; these interactions afforded a feedback mechanism that transcended various learning-to-teach contexts, supported experimentation, and precipitated a gradual increase in sophistication of ambitious practices as they refined these borrowed visions. Grossman and colleagues (2000) describe a similar group of 10 English teachers who appeared to adopt broad visions of practice from university coursework, engaged in standard teaching practices their first year, and then during their second year took up pedagogical tools from university coursework as they reassessed their "visions of ideal practices" (p. 657). In this way, the profile

and practice of this group of teachers is similar to the compartmentalized group. However, because the compartmentalized group continued to participate in the induction community, the tools and routines for closely examining student thinking with peers compelled them to recalibrate and extend their ideal vision of an ambitious practice during their first year of teaching.

For the integrated group (Trajectory 1), the tools themselves fueled experimentation and innovation with multiple ambitious practices. In fact, merely having access to a conceptual tool such as the framework for model-based inquiry helped them begin building a curricular vision during university coursework. In this way, these novices were "vision-forward" in their use of tools and routines; their curricular visions of what was possible helped guide implementation and experimentation with the tools at hand. Having made sense of the conceptual frames used in the university setting, they could begin to imagine how a range of productive practices—even ones we did not directly specify—could be enacted in classrooms. This group of teachers, however, was more likely to continue to use ambitious practices through their first year if the tool had both specified pedagogical and conceptual features.

For these teachers who adopted a student-thinking critical discourse in the preservice context, tools did not directly "act on" practice, rather they expanded these individuals' curricular vision, which in turn enabled experimentation with new practices. As noted by others in the fields of identity (Holland et al., 1998) and activity theory (Engeström, 2004), a community's tools can be used by individuals to foster innovation beyond normative practices. In the integrated group, innovations were structured around pedagogical techniques to reveal and "work on" student thinking—techniques that often went against their prevailing public school norms. This served to consolidate their identities as principled risk takers and as professionals whose defining characteristics included high expectations in the classroom as well as a relentless focus on student thinking. In summary, well-designed tools, as proxies for ideas and signaling membership in particular communities, can fuel the rapid refinement of critical pedagogical discourses—which in turn can catalyze the development of an entire repertoire of ambitious practices.

Revising a Theory of Ambitious Early-Career Teacher Practice

Understanding each trajectory along the three dimensions we have described problematizes current developmental theories that refer to a single professional trajectory with a continuum of stages from novice to expert (Bullough & Baughman, 1997; Feiman-Nemser, 1983; Hogan et al., 2003). Unlike these explanations, our model (Figure 2) accounts for variations in developing practice by recognizing the multiple forms of discourses teachers engage in and the influence of context, tools, and time on the professional trajectories.

Taken together, the three explanatory dimensions (affiliation within and across communities, development of critical pedagogical discourses focused on student thinking, and tools that support revisions to critical pedagogical discourses) extend Hammerness et al.'s (2005) framework for teacher development. Our revised theory begins with the premise that the early career of teachers is a time of pronounced growth and reorganization of thinking about one's role as a professional, the capabilities of students, the goals of instruction, and how to support learning. This ongoing identity work is mediated by multiple contextual discourses and critical pedagogical discourses. In all early learning-to-teach situations, novice teachers confront contextual discourses—institutional, social, and historical messages about teaching and learning—in the forms of norms, ideas, curricula, tools, and so on that can disrupt, support, or extend their critical pedagogical discourses. When a novel teaching practice, professional routine, or tool is introduced, it is considered in relation to one's critical pedagogical discourses. Where prospective ideas, tools, or routines appear equitable and ambitious, novices may negotiate not only the language of a productive new practice/tool, but also their tightly held theories of teaching in order to create new visions of practice for themselves. Developing a pedagogical affiliation and sense of membership in an ongoing reform community is vital to the development of novice teachers' critical pedagogical discourses, particularly when there is an ambient press for conservative forms of teaching. As we saw with teachers in the first learning trajectory group, critical pedagogical discourses that become organized around student thinking are most likely to support novices' taking up multiple practices associated with ambitious pedagogy and experimenting with innovative practice, even in an environment of oppositional contextual messages. On the other hand, critical pedagogical discourses that develop only around the execution of instructional strategies (even strategies aimed at supporting student reasoning) result in trajectories that do not readily incorporate ambitious practice.

Across time, some threads constituting critical pedagogical discourses play a central role in problem framing and decision making. Other, more peripheral threads either disappear or become incorporated with the more pronounced lines of discourse to form a robust system of logic to interpret the world and to act within it. This partially explains why individuals with focused critical pedagogical discourses are willing to enact forms of teaching (ambitious or not) in line with their critical pedagogical discourses despite contextual pressures to do otherwise.

Pedagogical tools and socio-professional routines are reifications of theories of action, values, and a stance toward inquiry. As unique expressions of contextual discourse, these tools and routines require coordination with critical pedagogical discourses. For most individuals, the appropriation of ambitious practice can be accelerated through the use of tools and routines that: embody pedagogical ideas congruent with ambitious teaching; focus

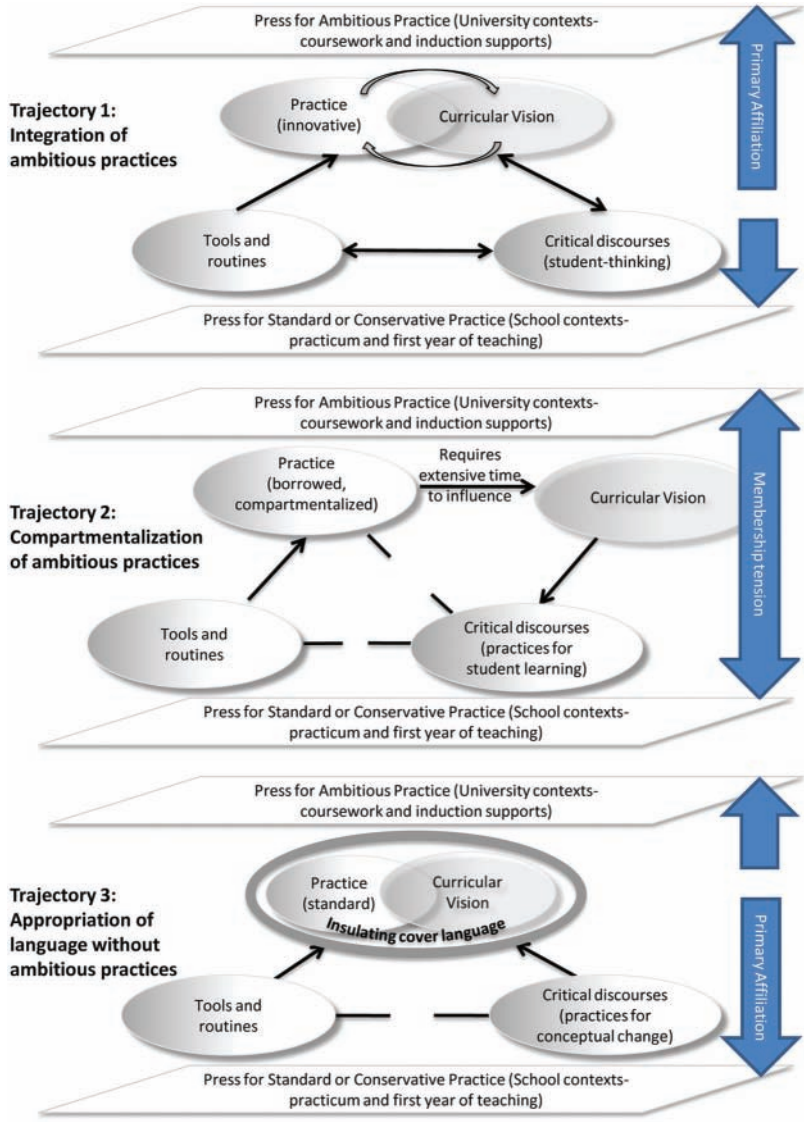

Figure 2. **Novice teachers' developmental trajectories of ambitious practices when negotiating conflicting contextual discourses.**

Note. Novice teachers differentially affiliated with communities in the university and school contexts (large arrows), developed different types of critical pedagogical discourses, and differentially used tools and routines within and across communities (processes indicated by smaller arrows or broken arrows).

on the relationship between teaching practice and student thinking; can be used directly to plan for, enact, or assess instruction; and are used in collaborative settings across preservice and in-service contexts.

Conclusions and Implications

Purposefully designed communities and tools that focus on ambitious practice throughout preservice and induction can have a major impact on novice teachers, just as they are beginning to select repertoires that will define them as educators. Two-thirds of the novice teachers in this study were able to develop forms of ambitious practice despite working in school environments with standard or conservative teaching practices. These findings differ from the literature about beginning teachers—that they are easily overwhelmed by context and regress rapidly toward conventional ways of teaching (Bransford & Stein, 1993; Brickhouse & Bodner, 1992; Hogan et al., 2003; Tabachnick & Zeichner, 1999). Specifically, previous studies have not followed teachers who have been systematically supported by communities or tools—a condition that is no longer acceptable for novices in the teaching profession. This gives us reason to question, as did Zeichner and Tabachnick (1981), current ideas about the "washing out" effect of reform practices promoted in teacher preparation. When focusing early career instruction on a set of core practices, supported by tools and routines over time, it is possible to interrupt such trends. Yet this study shows that there is no magic solution for helping novice teachers take up ambitious practices. It is not simply a matter of changing teachers' knowledge or engineering learning settings. What is needed is a more robust theory of teacher learning that accounts for how participation in different communities—that project different messages about instruction and learning—shapes the language and practices of novice teachers.

Implications for Research on Teacher Development

While specific contexts may provide tools and routines that can support reasoning with ambitious practices, this study suggests that a different conceptualization of "context" is needed to understand teacher development across learning-to-teach settings. How the influence of context persists across settings is critical. Contextual discourses do not switch on or off depending on the immediate setting one occupies; they remain "voices of mind" (Wertsch, 1991) that are constantly referenced—often several at once—as one weighs out pedagogical alternatives. By examining the interrelationships *between* critical pedagogical and contextual discourses over time, we can characterize why some teachers take up ambitious forms of teaching and others do not. This relational view may explain why, in this study, we did not see teachers fundamentally alter critical pedagogical discourses without the support of a community committed to developing tools

and routines around ambitious practices. In contrast, current theories of teacher development featuring characteristics that inhere to individuals, such as teacher's dispositions, beliefs, and ways of noticing, may not be sensitive enough to the underlying processes that shape and are shaped by participation in multiple professional communities. These individual characteristics are not always predictive of actual practice and can contradict what happens in classrooms (Simmons et al., 1999).

In terms of better articulating the role of context on teachers' trajectories, more research is needed to describe the influence of a continued press for ambitious practices and teachers' trajectories over the long term, particularly for Trajectories 2 and 3. It may be possible that the compartmentalized group could eventually adopt critical pedagogical discourses similar to those of the integrated group. Alternatively, they may not need to adopt a student-thinking critical pedagogical discourse to enact a modest repertoire of ambitious practices; they may simply have a slower rate at which they take these up—one isolated practice at a time. This part of our model remains a question. Furthermore, it is unclear if the nominal appropriation group (Trajectory 3) will ever develop ambitious practices. They will most likely continue to refine a repertoire of traditionally competent practices and accompanying critical pedagogical discourses but not adopt sophisticated pedagogy unless there is a dramatic shift in school contexts or they develop a compelling reason to doubt their practices and begin to listen to students' ideas for more than right or wrong answers.

Implications for Teacher Education and Induction

The idea that not all teachers were on a similar developmental trajectory suggests that there cannot be a singular approach to working with novice teachers. Teacher education and induction supports need to orient learning experiences around student thinking yet tailor tools and routines to different developmental trajectories of beginning teachers. It would be short-sighted, however, to conclude that teacher preparation and induction programs need only support the development of a "student-thinking" disposition or supply one-size-fits-all images of ideal ambitious practices. Even decomposing these practices into manageable steps for teachers to emulate (Grossman et al., 2009) is not sufficient for supporting all developmental trajectories. Our science learning framework and tools, for example, will most likely continue to *not* help teachers who develop critical pedagogical discourses around correcting students' ideas and having them reproduce textbook explanations. These teachers will need assistance uncovering and working with preexisting critical pedagogical discourses (Richmond et al., 2011) and understanding how their frameworks might fit with a student-thinking orientation.

Yet, the larger design challenge of teacher preparation is to go beyond "in-the-head" models of novice learning and ask: When, how, and in what

capacity do contextual discourses interface with developing critical pedagogical discourses? This will require understanding which contextual discourses offer opportunities for productive tensions and if a unique set of tools is required for this unaddressed task. Equally important is a need for consistent press for ambitious pedagogy across all phases of teacher education. Like much of the literature, this study suggests the need to provide continuity across learning-to-teach contexts and a need to work with K–12 schools to encourage and support principled experimentation during teaching practicum. Practicum is a vital time in teacher development; having aligned visions of ambitious practices across contexts is likely to benefit new teachers who are often caught between competing contextual discourses (Levin et al., 2009). While we have begun working with mentor teachers and district coaches to create a communally shared vision of ambitious practice, we believe this should be the means to a more important end—one in which teachers are pedagogically innovative with practice. Their pedagogical innovations in turn inspire us with what was possible in the classroom of the well-supported novice.

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