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# Keeping It Complex: Using Rehearsals to Support Novice Teacher Learning of Ambitious Teaching

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**Abstract**

We analyze a particular pedagogy for learning to interact productively with students and subject matter, which we call "rehearsal." Our goal is to specify a way in which teacher educators (TEs) and novice teachers (NTs) can interact around teaching that is both embedded in practice and amenable to analysis. We address two main research questions: (a) What do TEs and NTs do together during the kind of rehearsals we have developed to prepare novices for the complex, interactive work of teaching? and (b) Where, in what they do, are there opportunities for NTs to learn to enact the principles, practices, and knowledge entailed in ambitious teaching? We detail what happens in rehearsals using quantitative and qualitative methods. We begin with the results of our quantitative analyses to characterize how typical rehearsals were structured and what was worked on. We then show how NTs and TEs worked together to enable novices to study principled practice through qualitative analyses of a particularly salient aspect of ambitious teaching, namely, eliciting and responding to students' performance.

**Keywords**

mathematics teacher education, instructional practices, elementary teacher education

Like many university teacher educators (TEs), we take our goal to be preparing novices to engage in "intellectually ambitious instruction." Researchers working in the Consortium on Chicago School Research coined this term to group together a number of approaches to instruction, including "teaching for understanding," "intellectually ambitious teaching and learning," and "authentic pedagogy" in a study of the effects of this kind of teaching on student learning (Smith, Lee, & Newmann, 2001). Their premise was that if it was done consistently and well, such instruction should help K-12 students "develop in-depth knowledge of subject matter, gain higher-order thinking skills, construct new knowledge and understanding, and effectively apply knowledge to real-world situations" (Smylie & Wenzel, 2006, p. 7). This conception of the goals of instruction is consistent with that embraced more recently by the Common Core State Standards Initiative (2010), whose vision of students learning both rigorous content and disciplinary practices is currently driving reform in 44 U.S. states and the District of Columbia. Many skeptics wonder whether we can create the kind of teaching that would be required to consistently produce this kind of learning for every student. Ideas for *how* to create it, especially in institutions of higher education, are in short supply.

Accepting a more ambitious vision for student learning challenges TEs to prepare new teachers to do a kind of teaching[1] that most experienced teachers are not yet doing. Because universities are currently thought to be unsuccessful in preparing novices for practice,[2] we are faced with two challenges: preparing beginning teachers to actually be able to do teaching when they get into classrooms, and preparing them to do teaching that is more socially and intellectually ambitious than the current norm. In this article, we report on an effort to address these challenges within the setting of university teacher education. We analyze a particular pedagogy for learning to interact productively with every student

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around rigorous content, which we call "rehearsal." We situate our work in the field of elementary mathematics.

U.S. schools are permeated with the unambitious belief that not everyone can do serious mathematics (Delpit, 2012; McLaughlin & Talbert, 2006). Researchers have found that a shift away from this all too common assumption can be affected by membership in a community of practice with others who have similarly ambitious aims, use common tools, and share common interpretations of problems (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010; Stein & Coburn, 2008). Learning in the company of other teachers who value and investigate student work, treat students like sense-makers, and adapt teaching to learning has resulted in experienced teachers being able to maintain high expectations of all students and enact practices that accomplish high-level academic learning goals (Gutiérrez, 1996; Horn & Little, 2010; Strutchens, Quander, & Gutiérrez, 2011). These ways of teaching require commitment to a different, and perhaps more difficult, approach to teaching and learning.

Rehearsal, as we have designed it, is a social setting for building novices' commitment to teach ambitiously. The motivation to do things differently is as important as knowledge and skill to creating consistently ambitious practice, and that motivation depends on the social circumstances in which one learns and develops an identity as a particular kind of practitioner (Cole, 1995; Rogoff, Baker-Sennet, Lacasa, & Goldsmith, 1995). Rehearsal can involve novices in publicly and deliberately practicing how to teach rigorous content to particular students using particular instructional activities (IAs). It can provide a setting in which a TE can use performance as a site for guiding the collaborative examination of appropriate teaching actions (Lampert, Ghousseini, & Beasley, 2011; Lampert & Graziani, 2009).

We address two main research questions:

*Research Question 1*: What do TEs and NTs (novice teachers) do together during the kind of rehearsals we have developed to prepare novices for the complex, interactive work of teaching?

*Research Question 2*: Where, in what they do, are there opportunities for NTs to learn to enact the principles, practices, and knowledge entailed in ambitious teaching?

Our research methods involved systematically studying 90 rehearsal videos across three teacher education programs using a video-analysis tool. This tool enabled us to capture, in detail, the actions and interactions that occurred between TEs and NTs around both routine practices and the judgments novices were learning to make.

In reporting our findings, we show how interjections and exchanges happening throughout the rehearsal between NTs and TEs support novices to learn to do ambitious teaching. Although our focus has been on elementary mathematics teaching, the research we report here has relevance for the design of teacher education more broadly. We view this analysis as preliminary to presenting our findings of research currently underway on what NTs learn from rehearsals. As the pedagogy we are enacting is unusual, we find it appropriate to explain how it can work prior to examining what it can accomplish.

## Situating Rehearsals Within a System of Professional Preparation: Designing a Very Different Methods Course

As background for empirically examining what we have been able to do in rehearsals, we first describe the design of our mathematics methods courses and how rehearsals are situated within that overall design. The design is based on the assumption that mathematics teachers need to learn to elicit, observe, and interpret student reasoning, language, and arguments and to adjust their instruction accordingly to promote learning (Cengiz, Kline, & Grant, 2011; Franke, Kazemi, & Battey, 2007; Lampert, 2001; Parks, 2010). Supporting students' explanations requires teachers not only to provide sufficient time and appropriate tasks but also to press for justification and explanation *in response to* student performance (Kazemi & Stipek, 2001; Silver & Smith, 1996; Stein, Grover, & Henningsen, 1996). And the response of the teacher must do double duty: It needs to treat students as sense-makers to build the kind of relationship that will engage them in serious intellectual activity, and at the same time, it needs to push them toward higher order learning goals (Cohen, 2011; Scardamalia, 2002).

Working in methods courses in master's-level teacher education certification programs at three public universities in the United States—the University of California at Los Angeles, the University of Michigan, and the University of Washington—we began to develop a system of pedagogy for teaching and learning the kind of teaching we describe here. Through biweekly virtual meetings and biannual retreats beginning in 2008, we prepared ourselves to enact the system, and we analyzed records of our practice to collectively investigate what we did, why we did it, and with what consequences. These analyses informed future iterations of our work.

### *What We Intend to Teach: Using Practices, Principles, and Knowledge Adaptively in Relational Work*

The common intended curriculum in the methods courses across our three sites consists of a set of teaching *practices*, a set of normative *principles* to guide teachers' judgment in the use of those practices, and the *mathematical knowledge* needed to teach elementary content. The teaching practices

we work on include preparing for instruction in addition to the interactive work of launching an activity, managing materials and space, managing time and pacing, using body and voice, managing student engagement, positioning students as competent, eliciting and responding to student contributions, representing student thinking verbally and on the board, orienting students to one another, assessing student understanding, and managing transitions. The principles that guide the implementation of these practices in everyday teaching are conceived with the aim of maximizing students' access to learning important mathematics with meaning and using that mathematics to solve problems. These principles include treating students as sense-makers, designing instruction for all children to have equitable access to rigorous academic work in school, referring to clear instructional goals to guide interaction, being responsive to the requirements of the school environment while wrestling with the need to improve schools as institutions in a democracy, and attending to students as individuals and learners. Practices, principles, and mathematical knowledge must be used *in relation to one another*, not in isolation. Furthermore, they must be used *in relationships among teacher, students, and the content to be learned* (Lampert, 2001). Our challenge was to design all of these relationships into teacher preparation.

We reasoned that managing the multiple relationships inside of instruction would require novices to learn not only to establish routines for interaction but also to use good judgment when faced with the many unexpected elements that arise when particular students engage with particular subject matter. Successfully advancing every student's learning of complex performance involves building mathematical and social relationships in which it is possible to continuously assess and adapt teaching to what students know and are able to do (Black & Wiliam, 1998a, 1998b, 2012; Moss, Pullin, Gee, Haertel, & Young, 2008; Wehlage, Newmann, & Secada, 1996; Wiliam, 2011a, 2011b). The knowledge, skill, and principles necessary to elicit student performance and respond to it productively are not static; they develop as they are used in the form of "adaptive expertise" (Bransford, Derry, Berliner, & Hammerness, 2005). Learning to make judgments about what to do in a particular situation not only involves learning about students and how they engage with content but also requires learning to appreciate which elements of the situation matter (Feldman & Pentland, 2003). Improvised interactive performances are not simply created in the moment (Crossan, 1998; Patel, Kaufman, & Magder, 1996; Weick, 1998). They involve extended preparation in what Yanow (2001) calls "the rules of engagement" which are learned in interaction with others, observing others, and creating a "mutual, collective, interknowing."

In reviewing studies of the development of situationally appropriate knowledge and skill, Hatano and Inagaki (1986) observe that there is a continual back and forth between applying routine procedures and learning *how* to use those procedures appropriately in different situations. They argue that the improvement of adaptive performance requires a balance between repeated practice to develop the efficiency of routines and the development of conceptual understanding to be able to innovate and adapt to new situations. We might imagine that conceptual understanding can be developed in courses, and repeated practice happens when novices are in classrooms: However, Ericsson and his colleagues claim that a balance between the conceptual and the practical is learned though *deliberate practice*, a kind of instruction in and for practice that they have studied extensively in multiple complex domains (Ericsson, 2002, 2008; Ericsson, Krampe, & Tesch-Romer, 1993). Deliberate practice is not just repeated doing but cycles of repetition with feedback, where the feedback can bring conceptual elements to bear on particular problems. In analyzing how expertise at complex work develops, Dreyfus and Dreyfus (1986) point out, "As the novice gains experience actually coping with real situations . . . he or she begins to note, *or an instructor points out*, perspicuous examples of meaningful additional aspects of the situation or domain" (p. 177, italics added). Deliberate practice in the company of others (peers, more experienced teachers, and TE) helps the learner develop an organized system for knowing when, why, and how aspects of their competency are relevant to any particular situation. This organized system becomes the conceptual framework that guides adaptation and innovation in situations of uncertainty (Hatano & Inagaki, 1986). Who the novice interacts with under what circumstances while learning for practice shapes what can be learned and also determines whether he or she will have the motivation to use what is learned.

## *How We Teach It: IAs and Cycles of Enactment and Investigation (CEIs)*

Our design closely ties "coursework" and "fieldwork." As practice-focused TEs, we do some version of both. To learn the practices, principles, and knowledge that constitute our intended curriculum, and to learn to use them adaptively in relationships, we teach novices to enact particular IAs that travel back and forth between the methods course to enactment in schools (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010; Lampert & Graziani, 2009). These activities are chosen or designed to be *containers* for the practices, principles, and mathematical knowledge that NTs need to learn and be able to use in interaction with students. In some cases, the IAs that novices are learning could be thought of as warm-up activities, and in others they are the core of the mathematics lesson. Their structure scaffolds the novice to elicit student understanding and performance of mathematics and to make judgments about how to respond in principled, instructive ways. While bounding the complexities the NT will encounter, the IAs are designed to enable the participation of all students and for the novice to elicit and build on students' mathematical thinking while working on a range of mathematical ideas in number and operations in the

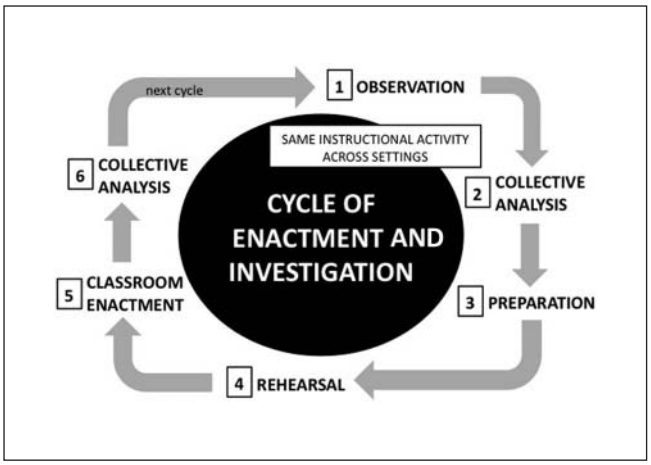


**Figure 1.** Cycle of enactment and investigation.

elementary grades. The IAs we teach include Choral Counting, Quick Images, Mathematical Games, Strings (sequencing computational problems), Strategy Sharing of Computational Problems, and Launching and Using Word Problems (Kazemi, Franke, & Lampert, 2009). This design feature structures what novices learn during deliberate practice in courses, and enables them to work collectively with a TE on preparing for and debriefing their work in classrooms.

At our three sites, TEs work with novices on the IAs in settings designed to support repeated CEIs, where novices repeatedly go back and forth between investigating teaching and enacting it (Grossman & McDonald, 2008; Lampert & Graziani, 2009). Using IAs enables the TE to better predict the particular challenges novices will encounter in enactment. The CEI (see Figure 1) begins with a class of NTs observing an enactment of a particular IA in a classroom context, either live or on video. Guided by the TE, the class then collectively analyzes the principles, practices, and mathematics that have been intentionally embedded in the IA they have observed and how those elements get integrated to address the particular teaching problems that arise. The next stage in the cycle involves novices in preparing to teach the same IA to engage a group of specific children in actual classrooms using the principles, practices, and mathematics they have studied in the context of the demonstration. After preparing, selected prospective teachers publicly rehearse their plans for enacting the activity in front of their peers in a setting that "approximates" full responsibility for a classroom of learners and a set of content learning goals (Grossman, Compton, et al., 2009). Next, novices interact with students, doing the activity they have rehearsed and video recording their work. This is an opportunity for the novice to test in practice the results of the public and collaborative preparation that occurred in the rehearsal in a setting where many of the ways in which students participate were anticipated. Another investigation by the group follows the individual enactments. The TE again guides a collective analysis, but this time, using records of NTs' practice to examine how the principles, practices, and mathematical content designed into the activity played out in a particular situation. The design of the elements of the cycle assumes that, in doing ambitious teaching and analyzing it, novices learn through building an iterative and interactive relationship between knowledge and principles, on one hand, and practical tools, on the other (Grossman, Hammerness, & McDonald, 2009).

The repeated engagement of novices and TEs in such cycles constitutes the "deliberate practice" critical for the development of adaptive competence. Novices get feedback from three sources: their peers, TEs who observe their teaching, and the students whom they teach. Over multiple enactments and analyses, the beginners learn which aspects of the structure of an IA remain relatively constant or "routine" and what parts of their performance need to be adjusted to what students know, what they are learning, and what they still need to understand and be able to do.

## *Zooming In On How Rehearsal Happens in the Cycle*

We began the empirical analysis of our developing design for a system of teacher preparation with a focus on rehearsal for several reasons. Rehearsal is the place in our design where the job of the TE is most different from the traditional work of supervising novices in classrooms or teaching them in courses. The way in which we do rehearsals is different from microteaching and from the "run-throughs" of novice designed lessons that are sometimes conducted in methods courses (Grossman, 2005).

In rehearsal, a NT is responsible for teaching an IA while the TE in the role of a simulated classroom student "acts back" in ways that intentionally represent the intellectual and social range of actions that might be anticipated in an actual lesson (Lampert & Graziani, 2009). Other novices participate, exhibiting their understanding of the children they are teaching. The simulation can represent the multiple relationships with students and content that might be in play, as well as the routine and spontaneous instructional interactions that must be managed in teaching. This structure presents the novice with instructional challenges ranging from the most basic to the more complex. The TE acts as both coach and simulated student, enabling both the rehearsing novice and the others in the group to investigate the actions a teacher might take in response to student performance. The TE has the opportunity to stop the action and coach the novice as he or she deliberately practices moves that are responsive to specific and multifaceted student actions. She[3] can also lead a discussion among the group of novices in which different possible moves are weighed for their appropriateness and potential effectiveness.

The discussion among the group gives rehearsing novices a community of practice within which to interpret what they

perceive about the work of ambitious teaching in the rehearsal. As a member of this community of practice, the novice develops his or her identity as a teacher with ambitious goals for all students. Even though working on such goals may not be common across the classrooms that novices experience, in rehearsal, they are accepted as normal. Believing in them and acting on them is what one does to become competent.

## Method

To examine how rehearsals enabled TEs and NTs to work together on the social and intellectual complexities of teaching, our analytic approach focused specifically on the interactional exchanges among TEs and NTs within rehearsals. We devised an analytic plan to capture the nuanced, interactional nature of the work while allowing for systematic analysis across a large data set. We developed a set of codes to track *what* was worked on (the *substance* of the interaction) and *how* it was worked on (the *structure* of the interaction). In many ways, our analysis parallels the investigation of what successful coaches do in preparing teams for interactive sports (e.g., Bloom, Crumpton, & Anderson, 1999; Lacy & Goldston, 1990) or what head residents do when they are preparing novice doctors to interact with, diagnose, and treat patients (e.g., Wilkerson, Lesky, & Medio, 1986; Young, Orlandi, Galicher, & Heussler, 2009). Both need to teach skills, knowledge, and judgment and how to use them interactively.

### *Sampling and Data Source*

We analyzed 30 video-recorded rehearsals from each of our three sites, creating a total database of 90 rehearsals. The 90 rehearsals were sampled from a larger pool of rehearsals occurring across a 3-year period in a way that represented our common practice; we considered length, the IA being rehearsed, the TE, and the settings in which rehearsals took place. Each site worked on multiple IAs that varied across sites and years. More than one TE led rehearsals at each of the sites. The setting of the methods class varied across sites and years; thus, rehearsals could have been held either at the university or at an elementary school where enactments of the IAs would take place on the same day. To select the 30 rehearsals from each site, we attended to these variations in rehearsals and sampled within site to create a representative sample of rehearsals based on the above dimensions for each site. This involved, for instance, sampling proportionally the number of rehearsals at a site that focused on each IA.

### *Coding and Data Analysis*

The use of Studiocode© video-analysis software allowed for detailed coding of interactions within video-recorded rehearsals and multiple analytic passes to track interactions that occurred across and within rehearsals. Studiocode is a software package that connects codes directly to segments of video rather than to supporting text documents such as transcripts. The central feature of Studiocode is a "timeline," which provides a chronologically organized multilayered graphical representation of all codes, descriptors, and narrative comments attached to a particular video. Members of our research group created Studiocode timelines for each rehearsal to capture the back-and-forth that occurred between NTs and TEs and to code what was being worked on within such interactions. Coding the video directly allowed for a variety of verbal and visual cues to be considered—intonation, gesture, body position, written representation, and so on—to comprehensively capture what was worked on in rehearsal and how it was worked on.

*Unit of Analysis: Identifying TE/NT Exchanges.* Figure 2 provides an example of a Studiocode timeline for one rehearsal with corresponding video and chart of codes and coding notes. Recall that we focused our analysis on the interactions between the TEs and NTs during rehearsals. We refer to these kinds of interactions during rehearsals as "teacher educator/novice teacher (TE/NT) exchanges." These TE/NT exchanges occurred in a number of ways and for a number of reasons, often initiated by the TE interjecting feedback in a novice's teaching performance, but at times initiated by a NT (e.g., to ask a question about what to do next). The timeline, located at the bottom of Figure 1, is composed of two rows. Row 1 shows the segments of the video during which the NT was leading the IA as a teacher with others participating as students, labeled as "NT Teaching." Row 2 comprises the segments during which there was a TE/NT exchange. A glance at the timeline as a whole reveals the back-and-forth nature of this in-the-moment work on practice: The NT would teach for a period of time then there would be a TE/NT exchange about the enactment, followed by the NT resuming teaching, and so on.

A close examination of the timeline reveals differences in the composition of rehearsal segments and thus the flow of NT teaching and TE/NT exchanges. For example, an exchange could consist of multiple conversational turns among the TE and NTs that pauses the simulation. *Example A* highlights such a segment in which, approximately 1 min into the rehearsal, there is an 8-s exchange that briefly interrupts the NT enactment. These exchanges typically involved the TE acting as a student and the NT responding as the teacher. *Example B* highlights a portion of the video where, during a lengthier segment of the NT rehearsing, the TE made three separate interjections during the flow of enactment, which did not stop the NT's teaching. These were common when, for example, the TE participated in the role of a student and shared a student's ideas to which the NT responded.

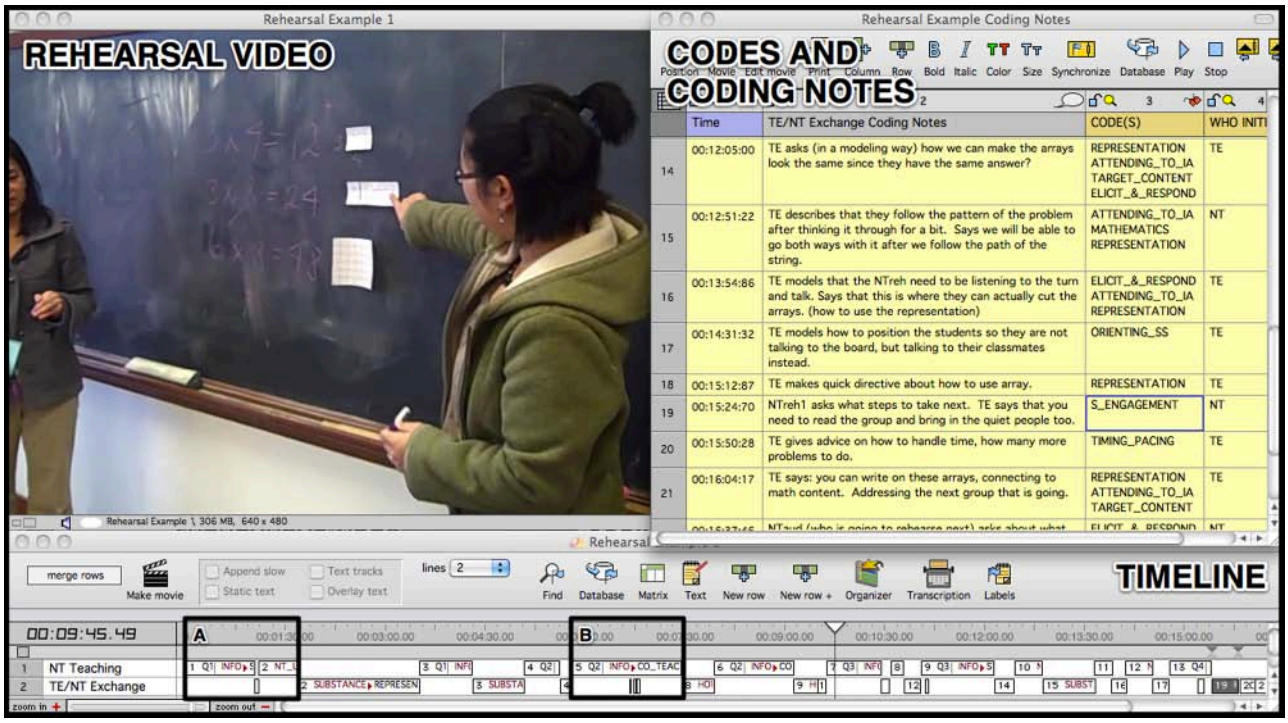


**Figure 2.** Example of a coded Studiocode "timeline" for one rehearsal.

*Coding TE/NT Exchanges.* We were interested in identifying the kind of guidance and feedback provided by TEs during rehearsal to better understand what could be meant by the *deliberate practice* in the learning of teaching (Ericsson et al., 1993). When did TEs give feedback? How did the feedback incorporate work on principles, practices, and mathematics? How did TEs deliver feedback? When did the NT step out of enactment to ask a question and about what issues? What aspects of practice were TEs and NTs working on together? To address these analytic questions, we coded both the form of the exchange (i.e., its *structure*) and its substantive focus.

*Structure codes.* The structure of the exchange was coded using four categories. The "TE gives directive feedback" category included exchanges where the TE directed the rehearsing NT by suggesting a next move or speculating possibilities for a next move. We coded "TE gives evaluative feedback" when the TE made an evaluative comment (either brief or more elaborated) that highlighted what was productive about a move or what could be improved on. The "TE scaffolds enactment" category applied to situations in which the TE either took on the role of the classroom teacher or a student to deliberately participate in the simulated activity, scaffolding the enactment by either increasing or reducing complexity of the ongoing engagement. Finally, we coded "TE facilitates discussion," when the TEs or NTs raised questions about learning and instruction that turned into a reflective discussion between the TEs and NTs in the midst of rehearsal.

*Substance codes.* Table 1 lists the substance codes used to track the substantive focus of TE/NT exchanges. This list represents a combination of a priori codes and codes that emerged from initial analytic passes through the data. For instance, "eliciting and responding" to students' mathematical ideas is a critical component of ambitious teaching, and we knew we would need to look for work on this within rehearsal. However, as we examined the rehearsal data, we noticed examples in which the TE intervened to support NTs attending to structural aspects of the IA to maintain the integrity of the task; thus, we added "attending to IA" as a code. While the substance codes topically reflect what we worked on, their meaning arises from examining the principled way we worked on those aspects of practice.

Because of the multifaceted nature of teaching, in many instances, we used multiple substance codes to capture the aspects of practice being worked on. For example, the TE/NT exchange in which the TE intervened to say "Now remember, Julia just shared that her strategy was different because she counted on from the 28 instead of starting at 1.

**Table 1.** Substance Codes.

| Code | Description | Example of TE interjection |
|---|---|---|
| Elicit and respond | Eliciting, interpreting, responding to student mathematical work or talk | "Michael said he knew 108 would come next as we're counting by 12. Ask him to explain *how* he knew that." |
| Representation | Representing mathematical ideas in writing and making connections between talk and representation | "Nice job annotating the array to match how you heard the student decompose the numbers." |
| Student engagement | Managing the intellectual and behavioral engagement of students | "An option we have here is to do a 'turn and talk' to see if we can get more students participating." |
| Attending to IA | Drawing attention to the structural aspects of the IA, particularly to help NT's understand the entire IA | "This would be a good time to start to ask students what they notice about all of the numbers." |
| Content goals | Attending to the specific mathematical content goals of the lesson | "Remember, we're pushing place value here. Raise your hand if you used tens in your strategy." |
| Student thinking | Attending to the details of student mathematical thinking | "Julia said she counted on from the 28 instead of starting at 1. Do you get the difference?" |
| Mathematics | Working on and understanding the mathematical content, particularly for NT learning | "What kind of a division problem is this? What is it that we're asking students to solve for?" |
| Student error | Surfacing and responding to student errors | "What if someone said 101 [an incorrect answer] instead of 110? How would you deal with that?" |
| Orienting students | Orienting students toward each other's mathematical ideas | "Hmm. Can someone else tell me how Ahmed knew where to stop counting?" |
| Process goals | Attending to the specific mathematical process goals of the lesson | "Remember we want to ask 'why' questions here to get kids to reason mathematically." |
| Launching the IA | Introducing and beginning student engagement with the IA | "Just a quick intro, then jump right into 3 times 4. We don't need anything lengthy here." |
| Assessing understanding | Assessing what a student knows and understands about the mathematics (formative assessment work) | "Check in with the group to see how many got that answer . . . What about a different answer?" |
| Manage timing | Moving through the lesson in a way that manages timing and pacing | "Yes, your pacing so far is great. You can always come back to the number line idea later." |
| Manage space | Attending to issues of classroom space while engaging students | "How could we set up the area so students can work on their white boards first and then talk in pairs?" |
| Body/voice use | Attending to how one uses body and voice while teaching | "It's always tricky figuring out where to stand so you don't block kids from seeing the board." |
| Closing the IA | Bringing the IA to an end | "Who has ideas about how we could bring this to a close? Let's get a few different ideas out." |

Note: TE = teacher educator; IA = instructional activity; NT = novice teacher.

Do you get the difference? How could you record that on the board?" would have been simultaneously coded with "attending to student mathematical thinking" and "working on representation." We also coded who initiated the interaction: the TE, the rehearsing NT, or another NT.

Reliability among coders was developed by having the entire research team coding a subset of videos and creating a codebook to resolve disparities. Research team members met biweekly and discussed coding disagreements until consensus was reached and codes could be operationally defined. Once the codebook was created, the codes were linked to video using Studiocode timelines, with at least two researchers coding each video and negotiating the final codes.

Our process of coding and analyzing Studiocode timelines provided flexibility to conduct a variety of analytic passes across our set of 90 rehearsals, including (a) broad quantitative passes that yielded descriptive statistics across the entire data set (e.g., *What did we commonly work on across all 90 rehearsals?*), (b) context-specific passes to understand the descriptive information across subsets of data (e.g., *Did the substantive focus of exchanges vary based on when they occurred in rehearsal?*), (c) substance-specific passes that examined when particular codes occurred simultaneously with other codes (e.g., *What was worked on in relation to our most frequent substance code "eliciting and responding?"*), and (d) detailed, in-depth passes that

investigated the qualitative nature of particular interactions (e.g., *How did we work on ambitious mathematics teaching when only "eliciting and responding" was coded versus when "eliciting and responding" was coded in relation to multiple other codes?*).

## Findings

We begin with the results of our quantitative analyses to characterize how typical rehearsals were structured and what was worked on. We then show, through qualitative analyses of a particularly salient aspect of teaching, namely, eliciting and responding to students' performance, how NTs and TEs worked together to enable novices to study principled practice.

### *Characterizing Rehearsals*

In this section, we use descriptive statistics to characterize the structure of rehearsals, the substance of rehearsal exchanges, and the roles adopted by the TE.

*Rehearsal Composition: TE and NT Participation.* The 90 rehearsals we analyzed were of varying lengths, taught by different teacher educators at three different sites, and focused on various IAs. Yet we found a number of commonalities across them. Rehearsals lasted on average 12 to 15 min with an average of 14 TE/NT exchanges per rehearsal. Roughly equal amounts of time were spent in NTs teaching the IA (56%) as in TE/NT exchanges (47%).[4] This balance between NTs leading the activity and interacting around that teaching is one indication of how the rehearsal structure facilitated deliberate practice. TE/NT exchanges lasted, on average, 27 s, though some were as long as 6 min and others as short as half a second (these extremes were rare).

An average of 14 TE/NT exchanges per rehearsal shows the back-and-forth pattern that occurred during the rehearsal. The NT's enactment of teaching was interspersed by brief TE/NT exchanges. In addition, 22% of the TE/NT exchanges were initiated either by the rehearsing NT (e.g., to ask about how many different student ideas to elicit) or by another NT (to raise a question, for example, about how to deal with an ongoing interaction). Thus, as TEs and NTs were interacting around teaching, such interactions were initiated by the TEs and the NTs. To understand that these interactions were not just initiated by the TE gives us some insight into how rehearsal functions as deliberate practice in the learning of teaching.

To see whether these patterns held across different portions of the rehearsals, we examined each rehearsal by quartile. That is, we analyzed the pattern of interaction within the first quarter of each rehearsal as compared with the second quarter, and so on. One might expect more TE/NT exchanges during the later portions of a rehearsal as the TEs provide more commentary; or one could predict the opposite as NTs ask questions and the TEs provide more guidance early on in the rehearsal. We found, however, that there was very little variability across the quartiles in the amount of TE/NT exchanges or the NT rehearsing, and the overall patterns that occurred across rehearsals also occurred within each quartile of the rehearsal.

**Table 2.** Frequency of Substance Codes, per TE/NT Exchange, and per Rehearsal.

| Substantive focus | % of all TE/NT exchanges ($n$ = 1,290)[a] | % of all rehearsals ($n$ = 90) |
|---|---|---|
| Elicit and respond | 35.74 | 95.56 |
| Representation | 23.64 | 77.78 |
| Student engagement | 21.55 | 85.56 |
| Attending to IA | 17.29 | 75.56 |
| Content goals | 14.03 | 57.78 |
| Student thinking | 13.95 | 71.11 |
| Mathematics | 11.94 | 71.11 |
| Student error | 8.60 | 30.00 |
| Orienting students | 7.05 | 47.78 |
| Process goals | 6.67 | 50.00 |
| Launching the IA | 6.20 | 37.78 |
| Assessing understanding | 5.12 | 43.33 |
| Manage timing | 4.34 | 37.78 |
| Manage space | 3.41 | 24.44 |
| Body/voice use | 2.95 | 24.44 |
| Closing the IA | 1.71 | 17.78 |

Note: TE/NT = teacher educator/novice teacher; IA = instructional activity.
[a]Recall that multiple substance codes could be applied to the same TE/NT to reflect the multifaceted nature of ambitious teaching; hence, this column does not sum to 100%.

*Substance of Rehearsal Exchanges: Opportunities to Learn What?.* Our first analytic pass to examine the substance codes involved analyzing the frequency of occurrence of each substance code. Table 2 presents this information organized in two ways: (a) per TE/NT exchange (the percentage of all TE/NT exchanges that included this substantive focus) and (b) per rehearsal (the percentage of all rehearsals that included this substantive focus—at least once during the rehearsal). The percentage of all TE/NT exchanges that included a particular substance code allowed for a characterization of the exchanges in terms of how often the substance was worked on across all exchanges, whereas the percentage of per rehearsal allowed for a characterization of how frequently a substance code occurred within a rehearsal, and thus its prevalence across all 90 rehearsals.

The substance codes show that the TEs worked with the NTs most regularly on the interactive work of *eliciting and responding* to students (36% of all TE/NT exchanges and 95% of all rehearsals). This finding reflects that this aspect of teaching was worked on uniformly across NT cohorts and IAs. Similarly, but with less frequency, *representation* and *student engagement* also occurred regularly across exchanges. While other aspects of teaching such as attending to *student mathematical thinking* (14% of exchanges) and *mathematics*

(12% of exchanges) occurred less frequently overall, they still occurred across more than 70% of all rehearsals. This reveals that, although these were not coded in as many instances, they were addressed in the majority of the 90 rehearsals. Still other codes appeared less frequently, yet they were worked on and are relevant. Overall, this table illustrates the terrain that TEs and NTs worked on together across 90 rehearsals.

*Single versus multiple substance codes*. We designed rehearsals to be able to work on the interactive and contingent aspects of teaching. Examining the frequency with which exchanges focused on one substance code versus multiple substance codes was one analytic way to begin to examine how we worked deliberately on the complexity of teaching. For instance, did a TE/NT exchange focus only on *eliciting and responding*, or did the intervention have more than one focus such as *eliciting and responding* and *orienting students to each other*? We found that 42% of exchanges involved only single substance codes suggesting that only one aspect of teaching was being highlighted and worked on. These single codes most often involved *eliciting and responding*, followed by *representation* and then *student engagement*. Together, these three codes accounted for 24% of all codes for TE/NT exchanges. *Mathematics* and *student errors* were the only other substance codes that were applied as single labels to more than 2% of our TE/NT exchanges (3% and 2.7%, respectively).

In comparison, 58% of the TE/NT exchanges involved more than one substance code, involving simultaneous work on more than one aspect of practice. In examining the combination of codes, we expected to find prominent pairings or groupings of codes. However, while we did find a few common combinations, such as *elicit and respond* with *student thinking* (3.4% of instances), what was more telling was that we found more than 350 *different* code combinations of up to 6 substance codes. So, more often than not, there was variation in the combinations of substantive foci being worked on. This is consistent with the notion that during rehearsal, the TE/NT exchanges occurred in relation to the NT rehearsing and in-the-moment situations that arose. As these situations varied often as a result of a deliberate interjection by the TE or a demand created by the structure of the IA for responsiveness to students and content, what was worked on in rehearsal did not follow a set pattern.

Our findings related to multiple substantive foci suggest that more than half of the time, the work in rehearsal not only addressed multiple aspects of practice simultaneously but also addressed them in relation to each other. While working on such aspects of practice in relation to each other was more common and could be expected, what was somewhat unexpected was the extensive number of unique combinations of substance codes that emerged from our analysis. For instance, while work on *eliciting and responding* was most common across rehearsals, there was variability in the other aspects of practice that were worked on in combination with this practice. The variability came from the mathematics being addressed, the NT rehearsing, the student thinking leveraged during the IA, and the fact that rehearsal was embedded in cycles that allowed observations from the enactment of the IAs in different contexts to get drawn into rehearsal.

**Table 3.** Characterizing the Structure of all TE/NT Exchanges.

| Structure category | % of all TE/NT exchanges ($n$ = 1,290)[a] |
|---|---|
| TE gives directive feedback | 60.85 |
| TE gives evaluative feedback | 28.14 |
| TE scaffolds enactment | 21.09 |
| TE facilitates discussion | 17.29 |

Note: TE/NT = teacher educator/novice teacher.
[a]These do not sum to 100% as TE/NT exchanges could include more than one structure code.

*Structure of Rehearsal Exchanges: Roles of the TE*. We examined the frequency of structure codes to display the distribution of roles the TE took on during rehearsals (see Table 3).

The most prominent type of interaction involved directive feedback from the TE to provide specific guidance to the rehearsing NT in the context of a teaching event. These interactions could involve specific requests for a next move as well as speculations about options that could be productive. Directive feedback, however, was not the only type of interaction that occurred during rehearsal and it did not characterize the majority of exchanges. The TE gave evaluative feedback a little more than one fourth of the time. Evaluative feedback often entailed a very brief highlighting of a NT's move, at times including more elaborated discussion about what went well or did not go well. When the TE scaffolded enactment, one fifth of the exchanges, she took on the role of the teacher or acted as a student. Participating this way allowed the TE to insert teacher moves that would be reasonable to use in certain situations or put into play possible student performances. When facilitating discussion, the TE or NT asked questions of the group about problems of practice, at times leading a reflection on why a move demonstrated by the rehearsing novice might be reasonable in the situation in conjunction with a consideration of the principles of ambitious teaching. These discussions often entailed much work on the development of the novices' judgment in adapting to the uncertainties of practice. Qualitative descriptions of the roles the TE played and the interactions that occurred with NTs during rehearsals are presented in the following section.

## Zooming In on Eliciting and Responding

Having used our coding to quantitatively characterize interjections and exchanges between NTs and TEs during all of the rehearsals in our data set, we now turn to qualitatively illustrating what it looked like to work on particular substantive aspects of practice within rehearsals.

We focus our discussion here on eliciting and responding to students' ideas for a variety of reasons. First, eliciting and responding to students' ideas is a salient component of ambitious teaching. Ambitious instruction necessitates that teachers facilitate children's interactions with one another and with content by making moves to make children's mathematical ideas available for public discussion in the classroom. Teachers must learn how to use those ideas to meet instructional goals while positioning children as competent. Teachers' skill in eliciting and responding to children's mathematical ideas is one significant way of treating students as sense-makers. Second, *eliciting and responding* was by far the most frequently occurring substance code across all TE/NT exchanges, as it was addressed in over one third of all exchanges and in 95% of all rehearsals. Clearly, focused work on eliciting and responding to students' ideas characterized a large portion of the collaborative work of TEs and NTs within rehearsals. Finally, *eliciting and responding* was a substance code that frequently occurred both as a single- and multiple-coded substantive focus. Comparing what was worked on in single- versus multiple-coded exchanges enables us to empirically convey what it meant to work on the complexity of teaching. We compared exchanges coded with *eliciting and responding* exclusively (10% of all exchanges and 26% of all *eliciting and responding* exchanges) to one that had eliciting and responding and two other codes (6% of all exchanges and 18% of all *eliciting and responding* exchanges). As we show below, this qualitative comparison highlights the different kinds of opportunities provided for TEs and NTs to work together on practice.

*Analysis of Exchanges With* Eliciting and Responding *As the Only Substance Code.* There were 124 of 1,290 exchanges coded with only *eliciting and responding*, and no other substance code. These exchanges were substantially shorter, on average, than the mean length of all the exchanges in our data corpus: 7 s compared with 27 s. To begin an iterative process of comparing and characterizing these instances, all of the instances were first reviewed and described qualitatively in order. We found that these exchanges were often initiated by brief TE interventions and fell into three categories.

In the first category, the TE participated as a student to offer examples of student thinking to which novices needed to respond (*TE scaffolds enactment*). In the following exchange, the group was sharing strategies for solving 32 + 40. The NT teaching the group elicited two ways to solve the problem, each involving the use of the number line. The TE then participated as a student, sharing a strategy that had not yet surfaced:

NT(Teacher):[5] Did anybody do that differently?
TE(Student): I sort of did something kind of in the middle. I took two jumps of 20.
NT(Teacher): You took two of 20? OK so . . . you wanted to take one jump of 20 [recording jumps on an open number line with two other strategies that have been shared] and then another jump of 20 and we still arrive at the same answer. OK, so there's three different ways that are very similar. They are just making different jumps.

The TE in this case scaffolded the enactment by presenting a student idea to which the NT would need to respond.

In the second category, the TE suggested what question to ask next or how to phrase a question (*TE provides directive feedback*). In this exchange, the group was counting up by fours. The NT leading the enactment stopped to ask how students were figuring out what number comes next in the count. She then directed the NT to make a particular teaching move.

NT(Student): I am adding 4 to the ones place only.
TE: See if anyone is thinking about it any differently.
NT(Teacher): Is anyone thinking about it differently than what Sara did?

This quick interjection by the TE directed the rehearsing NT to elicit other strategies, a move that was promptly taken up.

In the third category, the TE affirmed the suitability of the NT questions using a form of praise (*TE provides evaluative feedback*). In this exchange, the group was counting by threes starting at 55. The NTs in the group, participating as students, offered ideas about what they had noticed about the written number sequence and how that helped them know what number is next. The NT leading the activity followed up with a "why" question about the pattern they just shared.

NT(Student): I was just adding 15 to the first column.
NT(Teacher): [Marking on the count] So, 15, 15, 15. Does anyone know why that is. Why it's 15?
TE: That is a good "why" question.

The TE in this exchange explicitly affirmed the NT's pedagogical move by offering brief praise as she took note of the "why" question she posed.

These short interventions by the TE support NTs to learn *how* and *when* to ask children particular questions to elicit and make mathematical thinking public. When playing the role of a student, the TE draws on her knowledge of how children may participate in class discussions to prompt the NT to respond to a student's ideas. By providing direction while the novice is teaching, the TE helps the NT see what a productive next move might be. By affirming a novice's attempt at questioning, the TE quickly marks a move as a good choice. In contrast to the examples we will present next, it is important to notice that the novice's enactment is not interrupted in these brief interjections to discuss why

certain elicitations or responses are appropriate. Our analyses of these exchanges show us that there are times in rehearsals where the TE kept the flow of the enactment going yet still inserted opportunities to "get a feel for" how elicitation and response to students can happen.

*Analysis of Exchanges With Three Substance Codes, One of Which Was Eliciting and Responding.* Although we can identify important aspects of ambitious teaching such as eliciting and responding, orienting students to one another, aiming toward the mathematical goal, and so on, enacting them in relation to one another is what makes the work so complex. Closely examining exchanges that were coded with multiple substance codes gave us an analytic entry point to understand how we worked on the interactive contingent demands of teaching. We analyzed closely the 83 exchanges that were coded with *eliciting and responding* and two other substance codes simultaneously. Those 83 exchanges represent 6% of the total number of TE/NT exchanges in our data set. Each instance was first reviewed and described qualitatively to begin an iterative process of comparing and characterizing these instances. As in our overall data set, we found a myriad of distinct combinations of codes in this subset. In particular, within these 83 exchanges, there were 40 distinct combinations of three codes. This indicates that we worked on eliciting and responding in conjunction with a broad range of other aspects of practice. These exchanges were typically longer than the mean length of exchanges in our entire data set (39 s vs. 27 s) and therefore allowed more time for discussion about instructional decisions.

Our analysis indicated that the TE and novices worked on the relational nature of teaching by attending to eliciting and responding moves that (a) were contingent on the way mathematical ideas were being engaged by learners in a particular situation or (b) addressed multiple instructional demands simultaneously. Each exchange could be characterized in one or both ways. In these longer exchanges, the TE, when appropriate, worked with novices on how an instructional dialogue could unfold through a sequence of questions and responses. To illustrate this, we share two examples. First, we share an example of work on the relational nature of teaching, revealing that the TE's feedback communicated that teaching decisions are contingent on the mathematical ideas of particular learners. This example also shows one way that the TE supported the use of follow-up questions to press for students' partial mathematical explanations, as well as attend to the students' mathematical thinking and the mathematics.

We drop in on the 9th of 17 exchanges between the TE and the NT in one 13-min rehearsal, an exchange that lasts 30 s. The NT was leading a count by 12 starting at 12. We coded this exchange with three substance labels: *eliciting and responding, student thinking*, and *mathematics*. In this exchange, the TE helped the NTs experience what it might be like to (a) take up a pattern that the students might notice in the count ("the numbers are all even") and (b) respond with questions that engage the students' mathematical ideas and press for justification.

Just prior to the coded part of the exchange, the NT(Teacher) led her peers in a choral count and wrote the count by 12s on the board, starting with 12. She paused when the class got to 180 and elicited patterns from the class by asking: "Now that we have our three rows and we've added by 12s, can anybody tell me what they see off the top?" A short conversation unfolded between the NT(Teacher) and a NT(Student) about the observation that numbers are even:

| | | |
|---|---|---|
| 1 | NT(Student): | The numbers are even. |
| 2 | NT(Teacher): | The numbers are even. What does that mean? |
| 3 | NT(Student): | They have equal pairs. 2, 4, 6, 8, and then the 10. [NT(Teacher) underlines the 2, 4, 6, 8, and 0 in the ones place in the first five numbers of the count as she talks.] |
| 4 | NT(Teacher): | So every number? |
| 5 | NT(Student): | Yeah. |
| 6 | NT(Teacher): | Just in the ones place? |
| 7 | NT(Student): | Well they are divisible by 2 [inaudible]. |
| 8 | NT(Teacher): | [to the class] Anything else? |

The NT(Teacher) is following up on the student's idea that the numbers are all even (Line 2). The student elaborated further, offering another mathematical idea that the ones-place digits are divisible by 2 (Line 7). The NT then invited other contributions from the class (Line 8), after which the TE interjects and our coded TE/NT exchange begins:

| | | |
|---|---|---|
| 9 | TE: | So, why are the numbers all even? [pause] I would only ask that if I thought that my class knew even and odd, by the way. |
| 10 | NT(Student): | The numbers are even because the count started with a multiple of two. |
| 11 | TE: | So, that's important. What if we started with a multiple of two and added threes? Would they all be even? |
| 12 | NTs(Student): | No. |
| 13 | NT(Student): | You're adding a multiple of two. |
| 14 | TE: | Evens to evens, right? So, we start with an even and we add an even, so an even plus an even is always even? Is it always that way? |
| 15 | NTs(Student): | Yes. |
| 16 | TE: | Okay, we'll come back to that later. |

The TE asked why all the numbers are even. She quickly qualified this statement to explain she would only ask that

question if her "class knew even and odd" (Line 9), making explicit the contingent nature of the move on specific students' mathematical understandings. It is worth noting that the TE's "why" question (Line 9) differs from the NT(Teacher)'s original question "What does that mean?" (Line 2) because it pursues a justification for the observed pattern. When a student in the audience continued the conversation by offering that the numbers are even because the count started with a "multiple of two," the TE marked this statement as something to pay attention to, immediately suggesting a follow-up question to ask the students to push on that idea (Lines 10-11). This follow-up question engages the NTs in a possible way to respond to the child's explanation for why the numbers are all even that would maintain the mathematical press (Lines 12-15). The TE ended this exchange there, indicating that they were not finished considering the mathematical issues at play (Line 16). The TE in this exchange supports the NT's use of the types of questions that together attend to mathematical reasoning and build on students' understanding of even and odd numbers. The work of the TE in this example points to the ways in which opportunities were created in TE/NT exchanges to connect the work of eliciting and responding to teaching key mathematical ideas and to encouraging student thinking.

In the second example, the TE worked on the relational nature of teaching by attending to multiple goals simultaneously as the NT made decisions about how to elicit and respond to student thinking. In this example, we show how the TE supported the NT to manage students' intellectual engagement with the task at the same time that she paid attention to the features of the activity that she was leading.

The exchange took place during a 33-min long rehearsal. It was the 6th of 30 exchanges and lasts 41 s. The NT posed a sequence (what we call a "String") of mental math problems involving adding multiples of 10 by representing them on the number line. The sequence of problems was

26 + 10

26 + 20

26 + 30

This TE/NT exchange was coded: *eliciting and responding, student engagement*, and *attending to IA*. As the NT worked to elicit answers from her students, she conveyed to the TE how she was trying to stick with her goals for the IA. The TE pressed the NT to accomplish her goals for the IA at the same time that she managed students' intellectual engagement in the mathematics through her questioning.

As background to the coded exchange, we drop in when the NT(Teacher) posed the first problem to the NT(Student):

| | | |
|---|---|---|
| 1 | NT(Teacher): | 26 + 10. Ruby, what do you think the answer is? |
| 2 | Ruby: | 36 |
| 3 | NT(Teacher): | [Writing on board] 36. Does anyone have a different answer? Silent thumb. 36, everyone? OK. Daniel, how did you get 36? . . . What was your strategy? |
| 4 | Daniel: | I just added 10. |
| 5 | NT(Teacher): | OK, you just added 10 to 26 . . . So here's a number line to represent this problem in a different way [drawing an open number line on the board]. This is the number that we started with, 26 . . . and if we are going to add 10, we'll take a jump of 10 [drawing an arc and labeling with "10"] and that will take us to 36. So we are moving 10 more [sweeping her hand over the arc of 10] on the number line. |

As the NT enacted her plan, she began to provide mathematical explanations to the class, "We'll take a jump of 10 . . . so we are moving 10 more on the number line" (Line 5). Our coded TE/NT exchange begins when the TE interjects, prompting a dialogue between the TE and NT:

| | | |
|---|---|---|
| 6 | TE: | OK, now you just explained all that. Back up, now that you know what it is that you are working on, and figure out a way to ask us a question to get us involved. |
| 7 | NT(Teacher): | OK, 'cause I studied this [plan for the lesson] really hard last night, and this said to explain the language of the number line. |
| 8 | TE: | Explaining the language, yes, but that doesn't have to exclude us. So you can still ask us a question. |
| 9 | NT(Teacher): | OK. |
| 10 | TE: | Does that make sense? And I can tell you studied that really hard . . |
| 11 | NT(Teacher): | So we started at 26 and if I take a big jump on the number line, I'll get to 36. And how many numbers did I jump in this arc here? |
| 12 | TE: | So if we started at 26 and we added 10 . . . You could say, if we started at 26 and we know we landed on 36, what was the jump that we made to get from 26 to 36? |

The TE played a different role here than in our first example. Instead of engaging with the NT around how to phrase an elicitation and response to student thinking, the TE described

what she noticed the NT had done and invites her to think of a way to ask questions (Line 6). The TE noticed that the novice was doing the intellectual work for the students and asked her to consider her goal of making the use of the number line explicit at the same time that she uses questioning to engage her students (Line 8). The NT explained that she was trying to attend to the goals of the activity. She referenced her plan for the lesson—a plan she had "studied hard"—and recounts that it said, "Explain the language of the number line" (Line 7). The NT was trying to be faithful to her plan. The TE supported her attempts to explain the representation telling her that her explanation helped her get clear about what she wanted the students to notice (Line 6). In doing so, the TE conveyed the importance of understanding one's mathematical goals, and then pressed the novice to try to realize them, by eliciting an explanation and engaging the students intellectually instead of providing explanations to students (Line 12). Within these constraints, the NT needed to simultaneously use her knowledge of the goals and elicit student thinking to engage the students in important mathematical work.

In sum, our analyses of these examples show that rehearsals created rich opportunities for novices and TEs to learn to navigate the social and intellectually complex demands of teaching. Rehearsals are designed both for novices to try out enactments of IAs and interact with TEs to develop the judgment need to respond appropriately to student performance. Our quantitative and qualitative analyses show the broad terrain of practices that NTs and TEs traversed during rehearsals. The TE took on a range of roles during rehearsals. At times, the TE interjected briefly, keeping the flow of enactment going and allowing the NT to "get a feel for" the complex interactions that can occur among students and content. At other times, the TE and NT had lengthier exchanges to address the principled judgment entailed in managing the complexities of student performance.

## Discussion

In designing rehearsals to approximate ambitious teaching, to provide shared learning experiences, to develop adaptive performance, and to shape NTs' knowledge, skill, and identities, we ground teacher education centrally in clinical practice. Rehearsal is a designed pedagogy for teacher education, embedded in the larger design of a CEI, which moves the study of teaching back and forth between what normally happens in coursework and school-based experiences. Although rehearsal simulates practice with students, it can be considered clinical because novices engage in doing the work of teaching; in the cycle, it is followed by doing and debriefing teaching in actual classrooms, and the TE draws on what she knows of those classrooms to pose problems to the novice. Rehearsal creates a role for the TE right at the center of clinical practice, as she uses what she knows about learners and about teaching to prepare novices to use knowledge, skills, and commitments to interact with students productively. It is a pedagogy that bridges academic content and fieldwork by deliberately focusing on how the academic content novices learn in courses is used in working on school-based problems of practice. Our intention in the research reported here was to find out how that design played out across elementary mathematics methods courses in three teacher education programs. We found that it played out consistently, and that it enabled the approximation of ambitious teaching so that novices could learn to do adaptive teaching while developing their knowledge, skill, and identities.

### *Rehearsals As Designed Pedagogies for Approximating the Complex Relational Character of Teaching*

Rehearsals are an approximation of practice in which the NTs and the TE work together within the confined space of a deliberately designed IA. Rehearsals vary in length, focus on a range of different aspects of teaching, involve regular intervention, and require working on aspects of teaching in relation to each other and simultaneously. Our findings point to the structural aspects of rehearsal that support working on complex practice as well as the opportunities for TEs to scaffold NTs in learning that practice.

Grossman, Hammerness, et al. (2009) speculate that approximations like rehearsal would allow TEs to provide "coaching around more specific strategies" (p. 283), and we found that this was indeed the case. Rehearsal, as we enacted it, was a setting for teacher education in which a range of facets of practice from "where you stand" to "how you orient students to each other's mathematical ideas" could be given attention. The extent to which the range of substance codes emerged within and across rehearsals as practice was approximated demonstrates this attention to the different aspects of practice. It also demonstrates that the TE does not work on what might be seen as more routine aspects of practice (where to stand) without also working on some of the more complex aspects of practice (how to orient students' to one another's ideas). NTs thus have the opportunity to work on learning multiple aspects of the practice in relation to each other. Grossman, Compton, et al. (2009) also argue that approximations can be "designed to focus NTs' attention on key aspects of practice that may be difficult for them but almost second nature to more experienced practitioners" (p. 2078). Indeed, rehearsals as they were enacted in our three sites allowed NTs not only to attend to particular aspects of practice but also to attend to the variations of the practice as it relates to particular students and mathematical goals. This was apparent in the analyses of eliciting and responding. NTs might commonly learn about questions that elicit student thinking but in the rehearsals we designed they also had the opportunity to practice making judgments about two situations: when to ask which type of questions (exchanges

with one eliciting and responding code) and how to use complex elicitation sequences to accomplish particular goals or meet the needs of particular students (exchanges with three substance codes).

Approximations of practice can be categorized as more or less authentic based on a number of characteristics but those characteristics must be considered in relation to the teaching that one is trying to approximate (Grossman, Compton, et al., 2009). Our goal was that novices use rehearsal to practice the kinds of interactions involved in ambitious teaching before engaging in them with students in classrooms. In rehearsals, there is significant interaction between the NTs and TE, resulting in about only half the typical rehearsal consisting of teaching interactions happening in real time. As in the education of intending physical therapists studied by Rose (1999), there is a great deal of "strategic instructional attention" and "mediation of tasks" by the professional educator. While this may suggest that rehearsals are more "approximate" than they are "authentic," we argue that this structure supports authentic work of a different kind. The more the practice context that rehearsal affords can give novices opportunities to practice *ambitious* teaching, the more it is an authentic approximation of *ambitious* teaching. A novice in the midst of student teaching is certainly doing the work of teaching, but the potential lack of attention to principles and practices identified as central to ambitious teaching would make it a less close approximation. What is critical within rehearsals as we enacted them is that interactions between NTs and the TE support attention to, and thus enactment of, particular principles and practices during the deliberate practice of interaction around mathematics. The interruptions in rehearsal scaffold NT performances in ways that enable them to attend to a more complex set of demands. Even though interventions take time away from practicing student–teacher interaction around mathematics, the interaction is a closer approximation than would be possible if we did not intervene.

Our analysis highlights the differences between rehearsals in our three sites and another approximation of practice common in teacher education, microteaching. In microteaching, teachers practice an instructional segment, typically between 5 and 15 min in length, without interjection or intervention by peers or a TE. The practice is followed by self-assessment, peer discussion, and TE feedback. In rehearsals, NTs and TEs work together to try to realize ambitious practices in the moment (Grossman, 2005). Our rehearsals involve almost equal amounts of NT rehearsing and TE/NT exchange. Feedback and discussion is not saved to the end of rehearsals. Our rehearsals typically involved 14 TE/NT exchanges. In addition to ongoing intervention within rehearsal, it also differs from microteaching in that it is embedded in Cycles of Enactment and Engagement with the goal of supporting NTs to create a frame for developing the complex relationships among students and content that are required in teaching. In these cycles, rehearsal is surrounded by observing, analyzing, and planning to use an IA before it is rehearsed, then teaching it to students and debriefing that teaching afterward before trying it again.

### *Rehearsals As Designed Pedagogies for Developing Adaptive Performance*

Rehearsals, as we structured them, provided opportunities for the NTs to retry, reconsider, and receive feedback about aspects of practice they had accomplished and ones they could work on. This involved targeted work on the routine aspects of practice while also working on the more complex aspects of it. For instance, the NT had the opportunity to get better at creating representations of student thinking on the board while at the same time eliciting and responding to their mathematical ideas. Our analysis shows that the TE supports complex performance on the part of the novice during rehearsal using situational demands that arise from the structure of the IA, which is deliberately designed to scaffold the use of principles, practices, and content knowledge. The novice does not come up with a unique personally designed lesson to rehearse. The TE's work, like that of the NTs, is situated within shared practice. The TE can build out from the structure of the IA to support the NT to make progress and in relation to a set of goals for the NT. Within the rehearsal, the TE scaffolds the learning of practice by making moves to model an aspect of the performance task (step in and ask the next question as the teacher), to stop the flow and support the NT to attend to more aspects of the teaching task (ask the NT to try again but this time considering how to engage the students), or to put an idea on the table as a student that the NT has to address. This ability to scaffold adaptive performance, drawing on the IA as a common tool, allows for enhanced opportunities for the NT to approximate the complexity of teaching that aims to have students both reason about mathematics and learn new content. The scaffolding can press the rehearsing NT to consider what he or she is doing in relation to other aspects of practice or the underlying principles. This helps the NT and others in the rehearsal's audience to develop a shared conceptual framework that can enable adaptive performance.

### *Rehearsals As Designed Pedagogies to Support the Development of NTs' Knowledge, Skill, and Commitment*

In rehearsals, novices both "tried on" aspects of ambitious teaching and engaged collaboratively with the TE and other NTs about how to develop that practice. They had the opportunity to develop skill in eliciting a student's mathematical idea, or orienting students to each other, or pursuing students' understanding of a particular mathematical idea. They had the opportunity to hear the TE or their peers affirm that the work they were doing was in line with that of teachers

who value and investigate student work, treat students like sense-makers, and adapt teaching to learning. Through the conversational routines that structured rehearsals, the assumption that they would maintain high expectations of all students and enact practices that accomplish high-level academic learning goals was "normalized" (Horn & Little, 2010). They had the opportunity to work with the TE while the TE scaffolded them through a complex teaching sequence. They had the opportunity to see how the principled ideas underlying ambitious teaching are instantiated across different content with different students.

As NTs rehearse teaching, they engage in *knowing in practice* (Cook & Brown, 1999), connecting their own knowledge and relevant aspects of the context to put knowledge to use. The ability to engage in such work and see the consequences of one's actions on student learning has potential to shape teachers' identities toward practice. The TE's interventions in the form of affirmative comments and evaluative feedback build on these opportunities in the way they align the work of the novice with aspects of ambitious teaching. Taking on the principles of ambitious teaching in a public way and working with a group of peers and a TE to figure out how they play out in the moves one makes in response to students enables the novice to develop a professional identity as both a teacher and a continuous learner of teaching (Holland, Lachicotte, Skinner, & Cain, 2001; Rogoff et al., 1995). Working on problems of practice together is a way to learn the cultural norms of ambitious teaching as novices hold themselves and their peers responsible for principled enactment.

## Implications and Next Steps

The recent Blue Ribbon Panel Report of the National Council of Teacher Education begins with a radical assertion:

> The education of teachers in the United States needs to be turned upside down. To prepare effective teachers for 21st century classrooms, teacher education must shift away from a norm that emphasizes academic preparation and course work loosely linked to school-based experiences. Rather, it must move to programs that are fully grounded in clinical practice and interwoven with academic content and professional courses. (National Council for Accreditation of Teacher Education [NCATE], 2010)

Clearly, the time is ripe to develop images of what might be done in such programs. In this article, we have detailed the elements of one approach to teacher education aimed at interweaving clinical and academic preparation with clinical practice in ways that are consistent with the kinds of ambitious learning goals outlined in current reform efforts.

Rehearsal, as we have designed and developed it, addresses the dual challenge of *preparing beginning teachers to actually be able to do teaching when they get into classrooms, and preparing them to do teaching that is more socially and intellectually ambitious than the current norm*. Understanding what novices take away from this experience into their own classrooms is an obvious next step. We not only need to understand whether the novices we are teaching learn to enact the IAs that we practice in rehearsal, but we also need to go deeper. These IAs are chosen and designed to be containers for learning the principles, practices, and knowledge of content that underlie ambitious elementary mathematics teaching, broadly conceived. We need to know whether these principles, practices, and knowledge carry over into novices' classrooms, whether or not they are doing particular IAs. But as we conceive of the commitment to enact this kind of teaching as socially constructed, we need to understand what impact the schools and districts in which these classrooms are situated have on novices maintaining the capacity to do what they have learned.

We have documented what is possible by way of preparing new teachers to do an uncommon kind of teaching while working within university methods courses. We know that we can redesign teacher education in ways that allow new teachers to work on the nuances of interactional-related elements in practice. We can take what is seen as difficult about practice, especially for novices, namely, eliciting students' performance and building on it to reach content learning goals, and make it explicit. This allows us to work on it not just in individual coaching environments but also in collaborative study among peers.

What we have designed and developed occurred within particular courses. We need to understand whether the kinds of courses we were able to teach can be expanded into whole programs that are fully grounded in clinical practice where academic content and professional courses are interwoven. We might examine how the practice we developed as TEs working closely together over a number of years can be learned by new TEs and whether it can become the norm. We might examine what appropriate qualifications for becoming a TE might be. Although we were not able to investigate this aspect of our work here, the design for doing rehearsals within CEIs involves not only making changes in higher education but also making changes in school classrooms. We also need to document how our collaborations with schools enabled the work that was described here and examine how school personnel might become engaged as partners in this kind of work.

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## Notes

1. "Practice" has several meanings in the literature on learning teaching. We use them all in this article, and depend on the context for clarity (see Lampert, 2010).
2. Following Cohen, Raudenbush, and Ball (2003), we use the term *teaching* to refer to what teachers do in relationships with students and subject matter in environments. Teaching is the teacher's contribution to instruction, which is the activity system of relationships whose object is student learning (Cole & Engeström, 1997). Whenever we refer to "teaching" in this article, we mean teaching that aims to accomplish an *ambitious* vision of what learners should know and be able to do.
3. Since all of the teacher educators in our project were female, we will consistently use 'she' and 'her' when we refer to the teacher educator.
4. These do not sum to 100% due to overlap in teacher educator/novice teacher (TE/NT) exchanges and NT rehearsing.
5. Dialogue examples will identify both the speaker (TE or NT) and the role she was taking on within the interaction (student or teacher). When no role is specified for the TE, she is interjecting, as in when she provides feedback.

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