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Modeling and Explaining Content: Definition, Research Support, and Measurement of the *ETS*® National Observational Teaching Examination (NOTE) Assessment Series

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Abstract

This report reviews the scholarly and research evidence supporting the construct labeled modeling and explaining content (MEC), which is measured via a performance assessment in the *ETS*® National Observational Teaching Examination (NOTE) assessment series. This construct involves practices at the heart of teaching that deal with how teachers model and provide explanations for knowledge and skill in the course of instruction. The construct, supporting evidence, and measurement are organized around 4 dimensions: framing the work; demonstrating targeted processes, strategies, or techniques; supplying explanations and other narration during demonstrations; and using language, terminology, and representations. The paper concludes with a description of the MEC performance assessment.

Key words: high-leverage teaching practices, teaching performance assessments, teacher licensure, measurement of teaching

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Some of the content in this report is used in the following companion reports: *Eliciting Student Thinking (EST): Definition, Research Support, and Measurement of the* ETS® *National Observational Teaching Examination (NOTE) Assessment Series* (RM-16-06) by Yi Qi and Gary Sykes and *Leading a Classroom Discussion: Definition, Supporting Evidence, and Measurement of the* ETS® *National Observational Teaching Examination (NOTE) Assessment Series* (RM-16-09) by Margaret Witherspoon, Gary Sykes, and Courtney Bell.

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Modeling and explaining content (MEC) refers to two closely related practices at the heart of teaching. In common parlance, explanation constitutes an everyday activity of teaching. Teachers routinely offer explanations in relation to a wide range of questions, including *what*, *why*, *when*, and *how to*, among others. When teachers explain, they also engage in the practice of modeling. Again in common parlance, modeling occurs when teachers show students how to do many things. *Showing* is a physical activity in this sense, but teachers also model cognitive processes. They *think aloud* as they show students how to solve a mathematics problem or interpret a literary text. They develop repertoires of representations, models, metaphors, tasks, and examples for use in building student understanding in the disciplines of knowledge and for building students' academic skills.

The construct emphasizes teachers' mindfulness about the academic purposes they are pursuing with students and their capability in making learning "visible" in the sense of revealing for students how to learn the content (Hattie, 2009). Through their use of modeling and explanation, teachers assist students in learning not simply "that" but also "how to" as these terms refer to a range of cognitive processes, skills, and dispositions. By making their own thinking visible to students, they assist students in developing—and monitoring—the students' own thinking.

Explanation and modeling, then, are ubiquitous practices of teaching in formal and informal settings. But these practices raise a range of questions. What constitutes a good explanation? What makes modeling an effective practice of teaching? What are explanations composed of, and how do these elements contribute to student learning? Are these practices common across subject areas, or are they specific to particular subjects? Scholars and researchers have studied these and related questions, contributing a body of theoretical and empirical literature that provides illumination. We review main currents in this literature as these bear on our focal interest in the measurement of this construct.

A Performance Assessment

This report provides support for the MEC construct and its measurement in a performance assessment for licensure, the *ETS*® National Observational Teaching Examination (NOTE) assessment series, developed by Educational Testing Service (ETS). Before describing this construct in greater detail, however, we provide a brief preview of the assessment, for the reader to keep in mind. The MEC task type provides a virtual whiteboard interface with which the candidate interacts via iPad. The virtual whiteboard includes a variety of tools candidates can use including, for example, free drawing, text highlighting, and others. Tasks are based on high-leverage content (described below) in lower and upper elementary mathematics and English language arts (ELA), with candidates completing at least two tasks, one in each content area. Candidates are supplied electronic copies of directions for each task, including student work samples and texts relevant to the specified instructional segment of teacher-led explanation and modeling. Candidates are given 20 minutes to plan and prepare, then 7 to 10 minutes to perform the instructional segment. Their voices are audio-recorded, and their representations on the whiteboard interface are video-recorded. In this performance the candidate supplies all the content and is directed not to refer to hypothetical students in the target audience, a classroom of students. Based on a common rubric, raters judge the performance based on the combined audio and video evidence. Further details of this assessment are provided below.

The NOTE Assessment Series

This performance assessment is one part of a new licensure examination, known by its acronym NOTE, that includes a combination of performance assessments and assessments of the common and specialized knowledge used in teaching. The assessment has been developed by ETS; TeachingWorks at the University of Michigan; and Mursion, a firm that is pioneering the uses of interactive simulations for training, preparation, and assessment.

The NOTE performance assessments[1] are oriented around a set of high-leverage teaching practices identified by teams of scholars and teachers convened by TeachingWorks:

> High-leverage practices are the basic fundamentals of teaching. These practices are used constantly and are critical to helping students learn important content. The high-leverage practices are also central to supporting students' social and emotional development. These high-leverage practices are used across subject areas, grade levels, and contexts. They are "high-leverage" not only because they matter to student learning but because they are basic for advancing skill in teaching. (2016b, para. 2)

High-leverage practices are consensus representations across many efforts to define good teaching.

NOTE concentrates on what is termed high-leverage content, defined as “the particular topics, practices, and texts that have been proposed by TeachingWorks as foundational to the K–12 curriculum and vital for beginning teachers to be able to teach” (TeachingWorks, 2016a, para. 2). Such content, organized by subject area and grade level, is anchored in national and state standards for student learning that have been developed with input from key professional groups (see, for example, the Common Core State Standards [CCSS] Initiative, 2015a, 2015b). NOTE assessments focus on practices of teaching content based on samples of tasks and items from the relevant content domain. NOTE’s initial focus is on mathematics and ELA teaching at the elementary level.

MEC and the License to Teach

Assessment of MEC is part of a licensure examination for teaching. The purpose of licensure is to assure the public that individuals who practice an occupation have met certain standards (Clauser, Margolis, & Case, 2006; Raymond & Luecht, 2013). The focus is on standards of competence needed for effective performance (American Educational Research Association [AERA], American Psychological Association [APA], & National Council on Measurement in Education [NCME], 2014, p. 175). “Licensure requirements are imposed by federal, state, and local governments to ensure that those who are licensed possess knowledge and skills in sufficient degree to perform important occupational activities safely and effectively” (AERA et al., 2014, p. 174). Licensure examinations cover what is necessary but insufficient for practice, meaning that although not all of the competencies are assessed, those that are assessed are critical to effectiveness on the job. The content of licensure examinations typically is derived from job analyses that may be conducted in a variety of ways, usually involving current practitioners who judge how critical competencies are to effective practice.

Validation of test scores for a given purpose, including licensure, relies on what has been termed, following Toulmin (2003), an argument-based approach (Kane, 2004; Papageorgiou & Tannenbaum, 2016). In this approach, the claims for a licensure test are based on data or information provided by warrants, which are defined as the justification for intended inferences from the data to the claims. Warrants, according to Kane (2004), are generally not self-evident and so must be justified: “The evidence supporting the warrant is referred to as the *backing* for the warrant” (p. 149), as may be derived from theory or empirical research. Conducting research to support the measurement of constructs in licensure assessment is necessarily an ongoing enterprise because validity is a process through which evidence is accumulated and evaluated, not an end state or property of a measure or test (Kane, 2006).

An important question for licensure concerns how to establish the standard for entry to an occupation. Here, the warrant for a scoring rule "relies on an analysis of the likely consequences (positive and negative) of using the rule. The warrant for the scoring rule may be based mainly or exclusively on expert judgment" (Kane, 2004, p. 149), and a variety of methods for standard setting have been established (see Tannenbaum & Katz, 2013). ETS is conducting standard-setting studies to determine what is required for entry-level practice for MEC, which will not be taken up in this report. Although ETS also is surveying practitioners on the importance of MEC and other critical practices assessed in the NOTE assessment series, the purpose of this report is to marshal the research and scholarly literature that provides backing for the MEC construct and its measurement.

Construct Definition, Explication, and Rationale

This high-leverage practice involves making content and disciplinary practices (e.g., specific texts, problems, ideas, theories, strategies, and processes) explicit through explanation, modeling, representations, and examples. As described by University of Michigan (2016), making content explicit

> is essential to **providing all students** with access to fundamental ideas and practices in a given subject. Effective efforts to do this attend both to the **integrity of the subject** and to students' likely interpretations of it. They include strategically choosing and using representations and examples to build understanding and remediate misconceptions, **using language carefully,** highlighting core ideas while sidelining potentially distracting ones, and **making one's own thinking visible** while modeling and demonstrating. (para. 2, boldface added)

Several phrases from this description of MEC, as boldfaced above, are worth elaborating, because these appear centrally in the empirical and theoretical support for our claims below about the efficacy of this practice and appropriateness of the ways in which it is assessed.

Providing All Students

The phrase “all students” (University of Michigan, 2016, para. 2) highlights the universal benefits of this practice for various populations, including students with disabilities and English-language learners (Ball, Goffney, & Bass, 2005; Englert, Raphael, Anthony, Anderson, & Stevens, 1991; Lubienski, 2002; Schleppegrell, 2013). Students bring a wide range of social, cultural, and cognitive experiences to the classroom that have been found to influence their expectations and preferences for engaging with academic content (Ball, 1993b; Ball, Goffney, & Bass, 2005; Engle, Lam, Meyer, & Nix, 2012; Jackson & Cobb, 2010; Lubienski, 2002).

Opportunities for students to engage with academic content vary according to the specific problem-solving context and the extent to which norms for language use and discursive practice are explicitly shared (Ball, Goffney, & Bass, 2005; Engle et al., 2012; Jackson & Cobb, 2010; Khisty & Chval, 2002; Lubienski, 2002; Schleppegrell, 2013). For example, in Lubienski’s (2002) study of social class differences in student responses to an instructional intervention based on the National Council of Teachers of Mathematics (NCTM; 2000) *Principles and Standards for School Mathematics*, she found that teachers struggled to implement open-ended problems and whole class discussions because teachers failed to question assumptions about how different students would experience these practices. Specifically, students from families with lower socioeconomic status (SES) were more likely than their privileged peers to express frustration and confusion instead of confidence in their abilities to tackle difficult problems, eagerness to figure things out on their own, flexibility in exploring mathematical ideas and trying alternative solution paths, and willingness to persevere, as NCTM (2000, p. 21) has called for.

Lubienski (2002) offered several theories about the source of this difference, but the important point for our purposes is that it cannot be assumed that all students will experience instructional practices in predictable and uniform ways. Making content and disciplinary practices explicit requires teachers to surface assumptions and to explain unfamiliar approaches in order to make them accessible to all learners (Ball, Goffney, & Bass, 2005; Delpit, 1988; Jackson & Cobb, 2010; Khisty & Chval, 2002; Lubienski, 2002). As Delpit (1988) aptly explained, “If you are not already a participant in the culture of power, being told explicitly the rules of that culture makes acquiring power easier” (p. 238).

Integrity of the Subject

Attending to the integrity of the subject is also central; we conceptualize modeling as a family of related practices that are inextricably entwined with the disciplinary content being modeled (Ball, 1993a; Ball, Lubienski, & Mewborn, 2001; Charalambous, Hill, & Ball, 2011; Leinhardt, 1990, 1993). That is, it is not just content, but also the depth and flexibility in the teachers' understanding of it (also referred to as *content knowledge for teaching* or *pedagogical content knowledge*) that promotes conceptual learning and prevents students from developing superficial or distorted understandings (Ball, 1993b; Ball, Hill, & Bass, 2005; Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008). Such superficial or distorted understandings can result from inaccurate, misleading, or incomplete representations and explanations (Borko et al., 1992; Charalambous et al., 2011; Rowland, Thwaites, & Huckstep, 2003). Students who struggle with concepts tend to rely on more rigid problem-solving approaches that emphasize following rules over reasoning, which may enable them to use the procedure as a crutch to compensate for a lack of conceptual understanding (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Duffy, Roehler, & Herrmann, 1988).

Careful Use of Language

Using language carefully is also key, as language creates the distinctions between ideas that give rise to conceptual frameworks of what we know and how we know it, especially when it comes to the specialized languages that characterize discourse within an academic discipline (Bailey & Butler, 2003; Leinhardt, 1990, 1993). This aspect of making disciplinary content and practices explicit overlaps with the importance of attending to the integrity of the subject, as each discipline involves specialized language use and rules for evidence and meaning (Bailey & Butler, 2003; Leinhardt, 1990, 1993; Schleppegrell, 2013). Careful use of language attends to these disciplinary conventions while building academic vocabulary by making language and discourse practices accessible (and explicit) to all learners (Ball, 1993b; Charalambous et al., 2011; Khisty & Chval, 2002; Leinhardt, 1990, 2001; Schleppegrell, 2013). So-called metatalk involved in teachers' instructional explanations illuminates the covert cognitive and metacognitive processes that disciplinary experts use to solve complex problems, scaffolding students' abilities to engage in similar analytic and discursive practices (Charalambous et al., 2011; Collins, Brown, & Holum, 1991; Duffy et al., 1988; Leinhardt, 1990, 2001).

Making Thinking Visible

Finally, making one's own thinking visible to learners is the crux of both the effectiveness of this practice and the challenge of promoting its widespread adoption in P–12 education (Ball, 1993b; Borko et al., 1992; Charalambous et al., 2011; Cohen, 2015; Collins et al., 1991; Duffy et al., 1988; Greenleaf, Schoenbach, Cziko, & Mueller, 2001; Langer, 2001). Duffy and colleagues (1988) described the "usual form" of modeling as physically demonstrating completion of a task. Although many teachers may view a demonstration as sufficient to show students certain concepts or processes, both empirical research and professional literature highlight the importance of deeper cognitive and metacognitive talk to contextualize and explain the demonstration (Charalambous et al., 2011; Collins et al., 1991; Duffy et al., 1988; Englert et al., 1991; Greenleaf et al., 2001; Grossman, Cohen, Ronfeldt, & Brown, 2014; Grossman et al., 2010). The cognitive and metacognitive elements of teacher talk make explicit the disciplinary knowledge guiding the teacher's problem-solving choices and strategies. In Grossman and colleagues' (2010) study, for example, effective explicit strategy instruction strongly differentiated teachers with low (second quartile) versus high (fourth quartile) value-added to their students' ELA achievement test scores.

In their case studies of teacher candidate learning in educator preparation programs, Charalambous and colleagues (2011) found that limited or inflexible disciplinary knowledge and an unwillingness to question and reflect on their practice are at the root of novice teachers' challenges in providing high-quality instructional explanations. Specifically, even teacher candidates with strong content backgrounds struggle to unpack and elaborate their disciplinary knowledge in ways that are accessible for students.

Research has also documented naïve beliefs about ELA and mathematics among some teachers and students: for example, that some people are just "good" writers or that mathematics is using formulas to calculate problems rather than using discipline-specific reasoning to understand concepts (Ball, 1993b; Charalambous et al., 2011; Englert et al., 1991; Jackson & Cobb, 2010; Kinach, 2002). In Charalambous and colleagues' (2011) study, teacher candidates who held these and other naïve beliefs were less likely to work to deepen their knowledge or to analyze and reflect on their practice in order to model and explain the content in accurate and complete ways. Although evidence from this study was limited in terms of its sample size and nonexperimental design, it supports the conjecture that many novice teachers struggle to think aloud about disciplinary concepts and unpack their reasoning so that it is accessible to all students. Consequently, we argue that it is important that teacher candidates demonstrate an acceptable level of competency with this high-leverage practice prior to entering the classroom.

Summary

These ideas form the crux of this construct, which is central to one of the fundamental purposes of teaching. A small but growing and robust literature has emerged that begins to define the practices that effective teachers employ as they develop deep connections between the academic content of instruction and the ways students learn that content. Clearly, teachers rely on their own knowledge of the content, but their instructional practice relies on more than just this knowledge. Rather, teachers develop particular practices in making content explicit for students, involving how they represent, explain, and model the content and the cognitive and metacognitive processes through which students learn.

General Support for MEC

If MEC is central to teaching, we might expect to find this practice in standards for teaching and learning and in both general and subject-specific observation protocols and evaluation instruments. Such evidence would provide an indication, from a broad consensus of experts in the field, that MEC is a central practice of effective teaching. This proves to be the case.

Many states today have adopted the CCSS (CCSS Initiative, 2015a, 2015b) of learning in mathematics and ELA, or similar versions. Such standards do not directly reference teaching practices, but they do provide indirect support. We argue that if teachers are to facilitate the learning expressed in such standards, they must provide effective explanation and modeling. For example, the CCSS Initiative (2015b) for mathematics is based on the idea of a “mathematically proficient student” who can “make sense of problems and persevere in solving them” (p. 6). To this end, the standards call on students to explain to themselves the meaning of problems, make conjectures, monitor and evaluate their progress, and check answers using different methods. Students are to “construct viable arguments and critique the reasoning of others” (CCSS Initiative, 2015b, p. 6). This mathematical practice involves students in analyzing “situations by breaking them into cases,” where they “can recognize and use counterexamples” (CCSS Initiative, 2015b, p.6). They know how to justify their solutions and respond to the arguments of others. “They reason deductively and make plausible arguments that take into account the context from which the data arose,” and they “attend to precision” (CCSS Initiative, 2015b, p.6) in their use of language, definitions, and symbols they choose. “They are careful about the units they measure,” “express numerical answers with precision,” and “give carefully formulated explanations to each other” (CCSS Initiative, 2015b, p. 6).

These and similar descriptions drawn from the standards for mathematical practice have clear implications for instruction. If students are to explain their reasoning, teachers must model how to do this. If students are to learn how to argue, conjecture, evaluate, provide examples, and use mathematical language with precision, they must be taught how to do these things, then given opportunities for practice with feedback. Teachers’ capability in modeling these practices and providing explanations for critical concepts and processes is evidently relevant.

Likewise, the CCSS Initiative (2015a) for ELA provides a set of anchors for the grade-specific standards in reading, writing, listening, and speaking. These anchor standards indicate that students are “to read closely to determine what the text says explicitly and to make logical inferences from it”; “determine central ideas or themes of a text and analyze their development”; “analyze how and why individuals, events, and ideas develop over the course of a text”; “interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings”; “analyze the structure of texts”; “assess how point of view or purpose shapes the content and style of a text”; “delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence”; and “analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take” (CCSS Initiative, 2015a, p. 10).

These are challenging and complex literacy practices that the ELA standards build progressively over the grade levels. These standards state explicitly that they do not define “how teachers should teach” (CCSS Initiative, 2015a, p. 6), but again we argue that certain implications for instruction seem apparent. Much of the learning that is projected involves cognitive skills such as interpretation, analysis, and evaluation in response to particular literary and informational genres. Teachers model these skills explicitly when they provide opportunities for students to practice them. They narrate what they are doing, compare performances, and provide exemplars for students to study. As they engage in this work of teaching, they interweave explanations for what they are doing, in the course of which they use language carefully, both to communicate clearly with students and to model such usage for them. A basic rationale for the importance of MEC relates directly to the standards for learning that states are adopting.

More directly, this core practice of teaching is referenced repeatedly in the Interstate Teacher Assessment and Support Consortium (InTASC) standards for teaching (Council of Chief State School Officers [CCSSO], 2013) that many states have adopted. For example, Standard 4(a) reads, “The teacher effectively uses multiple representations and explanations that capture key ideas in the discipline, guides learners through learning progressions, and promote each learner’s achievement of content standards” (CCSSO, 2013, p. 24). Standard 6(f) states, “The teacher models and structures processes that guide learners in examining their own thinking and learning as well as the performance of others” (CCSSO, 2013, p. 30). And Standard 8(e) calls for the teacher to provide “multiple models and representations of concepts and skills with opportunities for learners to demonstrate their knowledge through a variety of products and performances” (CCSSO, 2013, p. 38). For the intermediate level of this standard, the teacher models higher-order questioning skills related to content areas (e.g., generating hypotheses, taking multiple perspectives, using metacognitive processes), and engages learners in activities that develop these skills” (CCSSO, 2013, p. 40).

Likewise, the widely used *Framework for Teaching* (Danielson, 2013) introduced element 3(a) “Communicating with Students,” in part, as follows:

> When teachers present concepts and information, they make those presentations with accuracy, clarity, and imagination, using precise, academic language; where amplification is important to the lesson, skilled teachers embellish their explanations with analogies or metaphors, linking them to students’ interests and prior knowledge. Teachers occasionally withhold information from students (for example, in an inquiry science lesson) to encourage them to think on their own, but what information they do convey is accurate and reflects deep understanding of the content. And teachers’ use of language is vivid, rich, and error free, affording the opportunity for students to hear language used well and to extend their own vocabularies. Teachers present complex concepts in ways that provide scaffolding and access to students. (p. 55)

Providing further detail, the *Framework* (Danielson, 2013) indicated that

> skilled teachers, when explaining concepts and strategies to students, use vivid language and imaginative analogies and metaphors, connecting explanations to students' interests and lives beyond school. The explanations are clear, with appropriate scaffolding, and, where appropriate, anticipate possible student misconceptions. These teachers invite students to be engaged intellectually and to formulate hypotheses regarding the concepts or strategies being presented. (p. 55)

Another general or generic observation protocol, the Classroom Assessment Scoring System (CLASS; Pianta, Hamre, & Mintz, 2011), draws attention under "Content Understanding" to how teachers provide "clear and accurate definitions," "effective clarifications," "effective rephrasing," "multiple and varied examples," "contrasting non examples," and "conditions for how and when to use the concept or procedure" (p. 65). Further, under "Analysis and Problem Solving," the protocol indicates that teachers "model thinking about thinking" (Pianta et al., p. 75).

Several prominent subject-specific observation protocols also prominently feature MEC. One of the 13 elements measured by the Protocol for Language Arts Teaching Observation (PLATO; 2013), "Representation of Content," focuses on the teacher's ability and accuracy,

> in representing ELA content (reading, writing, literature, grammar/mechanics, and oral communications) to students through effective and meaningful explanations, examples, and analogies, along with the conceptual richness of the teacher's instructional explanations. Only publicly visible representations of content should be factored into scoring (i.e. examples in textbooks or on worksheets that are not discussed as a class should not be factored into a segment's score). At the lowest level, the teacher may introduce ideas (i.e. close reading, editing, symbolism), but either does not provide any examples or explanations or provide incorrect examples or explanations. At the highest level, the teacher provides clear and nuanced explanations and helps students distinguish between different but related ideas, and the instruction focuses on conceptual understanding of ELA content. (bullet 3)

As well, the Mathematical Quality of Instruction protocol (MQI; 2012) includes reference to errors and imprecision in language or notation and lack of clarity in expression. Under the dimension referred to as richness, it says that "richness includes two elements: attention to the meaning of mathematical facts and procedures and engagement with mathematical practices and language" (National Center for Teacher Effectiveness, 2012).

Finally, in the program of research addressing teachers' content knowledge for teaching (see Phelps, in press), one of the eight tasks of teaching includes "explaining concepts, procedures, representations, models, examples, definitions, and hypotheses" (Gitomer, Phelps, Weren, Howell, & Croft, 2013, p. 498). These measures also are specific to the subject matter of mathematics and ELA, respectively.

Looking across these descriptions, several features stand out. They call for teachers to have clear purposes in mind; to use accurate, precise academic language; to provide multiple ways of explaining content; to connect explanation and modeling to students' prior knowledge and understanding; and, through modeling, to scaffold student understanding. There is an emphasis on teachers' ability to make public and transparent their explanations and to make visible their modeling of concepts and skills. Convergence across multiple instruments of this kind provides one kind of support for these features as common hallmarks for effective modeling and explanation. But we can also ask whether such features emerge in the theoretical and empirical literature on MEC.

Research and Measurement of MEC

We next review the research literature supporting the critical dimensions of this practice. Modeling and explaining typically go hand in hand as teachers integrate substantive understanding of disciplinary concepts and ideas with disciplinary practices and as they pursue both cognitive and metacognitive goals with students. In this work, they must (a) frame the instructional activities for students; (b) provide demonstrations of various kinds for processes, strategies, and techniques; (c) offer explanations involving representations, examples, models, metaphors, and the like while they are engaged in demonstrating skills; and (d) use academic language and terminology accurately and precisely that is attuned to students' prior understanding. These four dimensions of the construct organize the review of the literature that follows and also show how these dimensions have been measured in previous research.

Aspect 1: Framing the Work

Framing outlines the content to be learned while calling attention to key concepts and highlighting connections between various parts and with prior learning and experiences (Brophy & Good, 1986; Collins et al., 1991; Kyriakides, Christoforou, & Charalambous, 2013). Framing is intended to orient students to the learning, activate prior knowledge, and promote transfer of learning between various contexts (Collins et al., 1991; Engle, 2006; Engle, Nguyen, & Mendelson, 2011; Hammer, Elby, Scherr, & Redish, 2005).

Framing a lesson or segment of instruction involves reviewing learning objectives, outlining the content that will be covered while calling attention to key concepts, and summarizing these ideas at the close of the lesson (Brophy & Good, 1986; Kyriakides et al., 2013; Rosenshine & Stevens, 1986; Schoenfeld, 1983). A meta-analysis of teaching practices indicated that structuring or framing an instructional segment is an effective teaching strategy (Kyriakides et al., 2013). Teaching researchers have postulated that reviewing content upon closing integrates and reinforces the intended learning taking place (Brophy & Good, 1986) and focuses students' attention on the most important parts (Collins et al., 1991). Lesson closure is also emphasized as a key aspect of instructional quality in the professional teaching literature (e.g., Webster, Connolly, & Schempp, 2009) and has been associated with improved student achievement (Brophy & Good, 1986; Kyriakides et al., 2013). The structuring or framing elements of the lesson are hypothesized to facilitate holistic understanding of the concepts while highlighting interrelationships among constituent parts (Kyriakides et al., 2013).

Framing current learning episodes as building upon past ones and linking to future content helps students understand the interconnectedness of their learning, facilitates the activation of prior knowledge, and promotes transfer to other content areas (Collins et al., 1991; Engle, 2006). Several different terms for this kind of framing appear in the literature. Engle and her colleagues (2012, 2011) referred to it as *expansive framing* because it highlights intercontextuality to encourage learners to transfer what they know to other related contexts (Engle et al., 2011, p. 605). Expansive framing is contrasted with *bounded framing*, in which learning contexts are narrowly defined as single events. Biology students in the expansive framing condition in Engle and colleagues' study (2011) were more likely to transfer science concepts, representational strategies, and prior knowledge than those in the bounded framing condition.

Similarly, Hammer and his colleagues (2005) defined a *unitary ontology* as one in which "knowledge or ability [i]s a thing that an individual acquires in one context and may or may not bring to another" (p. 4). Unitary ontology is contrasted with a *resources-based ontology*, in which learning is a cognitive state "involving the activation of multiple resources" (Hammer et al., 2005, p. 5). A resources-based perspective on learning facilitates transfer and prepares students for future learning (Hammer et al., 2005). Work of this kind supplies some theoretical support for the practice of framing.

Making explicit the relationships among instructional activities and their purpose in supporting learning objectives is a key evidence-based teaching strategy (Sykes & Wilson, 2015). Teachers coordinate classroom activities around an area of instructional focus to help students organize and monitor their learning (Charalambous et al., 2011; Goldenberg, 1992; Leinhardt, 2001; Leinhardt & Steele, 2005), which in turn promotes learning, as some studies have found (Ball, Hill, & Bass, 2005; Bransford, Brown, & Cocking, 2000). Successful implementation of this practice begins with planning and sharing explicit learning goals for student activities, which may be based on state standards for learning. Research on explicit instruction also supports the importance of beginning lessons with clear statements of the purpose and goals or expectations for student learning (Archer & Hughes, 2011; Brophy & Good, 1986; Gersten, Schiller, & Vaughn, 2000; Swanson, 2001). This practice focuses students on the intended learning about to take place and provides guidance for them to monitor their own learning. Studies have shown that all students—including those with special needs or language barriers—benefit from instructional practices that promote their abilities to monitor their own learning (for review, see Sykes & Wilson, 2015).

Theorists have proposed that teacher-led modeling can frame an instructional episode by activating prior knowledge and preparing students to focus on key aspects of the learning (Collins et al., 1991; Englert et al., 1991; Kyriakides et al., 2013; Schoenfeld, 1983). Teacher modeling of the process involved in solving an unfamiliar problem provides an advance organizer of the practice that students will develop, an interpretive structure for feedback, and an internalized guide for independent work (Collins et al., 1991). Modeling of a full problem-solving strategy includes not just the solution, but appropriate context for students to understand how and why the strategy is useful. Without this information, students do not gain access to the metacognitive (or control) strategies necessary to use the strategy independently (Bransford et al., 2000; Collins et al., 1991; Duffy et al., 1988; Englert et al., 1991; Hammer et al., 2005; Walshaw & Anthony, 2008). As these studies suggest, the teacher's goal is sufficient transparency in her strategic choices to enable students to subsequently and independently make similarly well-informed strategic choices, rather than just to replicate her actions. Some evidence, drawn largely from observational studies, supports these conjectures that arise from this theoretical approach grounded in cognitive science (see, for example, Walshaw & Anthony, 2008; Hattie, 2009).

Aspect 2: Demonstrating the Targeted Process, Strategy, or Technique

Duffy et al. (1988) provided an early conceptualization of modeling that consisted solely of physically demonstrating the completion of a task. The authors offered as an illustrative example the practice of uninterrupted sustained silent reading (USSR), or time set aside during the school day for both teacher and students to read recreationally. The teacher would "model" for students her own enjoyment of silent reading, with the goal of students inferring the pleasure of reading by observing her physical behavior.

Similarly, Wood, Bruner, and Ross (1976) described a tutor as an expert who demonstrates or models. "In this sense, the tutor is 'imitating' in idealized form an attempted solution tried (or assumed to be tried) by the tutee in the expectation that the learner will then 'imitate' it back in a more appropriate form" (Wood et al., 1976, p. 98). Although the authors expected this hypothesized demonstration to elicit blind matching of tutee behavior to the tutor's, this did not occur, leading them to conclude that the "occurrence [of imitation] depends upon the child's prior comprehension of the place of the act in the task" (Wood et al., 1976, p. 99). That is, showing the students what to do was not sufficient for them to understand what they were doing. These early studies opened up inquiry around the idea of modeling, leading to more recent contributions that undergird the MEC construct.

Such studies suggested that simple showing is not sufficient in itself to promote learning. More than simple imitation is involved as unseen cognitive processes come into play. Englert and colleagues (1991) traced the history of thinking aloud to its roots in Vygotsky's (1978) conceptualization of the development of inner or egocentric speech. According to Vygotsky, inner speech is an important mental activity in planning and regulating one's actions. Inner or egocentric speech emerges first in a social dialogue that takes place between an adult or teacher and a learner. Initially, the adult models the inner dialogue while completing most or all of the cognitive work (Englert et al., 1991). In time, the learner participates in a collaborative social exchange by assuming responsibility for some aspects of the work. Vygotsky proposed that eventually, this collaborative exchange becomes internalized, giving way to covert and automatic self-guiding speech that requires little conscious thought.

More recent work, then, goes beyond simply showing the student what to do, to include the use of an explanation of the underlying processes in addition to demonstration. Collins and colleagues (1991) defined modeling as "an expert's performing a task so that the students can observe and build a conceptual model of the processes that are required to accomplish it," emphasizing that "in cognitive domains, this requires the externalization of usually internal processes and activities" (p. 11). The think-aloud component of modeling enables teachers and students to articulate—to make explicit—the usually invisible strategies and reasoning that enable an expert to apply his or her knowledge. Modeling allows teachers and students to delve more deeply into the concepts and strategies involved, while simultaneously revealing any gaps in understanding that may be interfering with higher level thinking (Collins et al., 1991).

A prominent example of this contention is the idea of a *cognitive apprenticeship* that includes four elements: modeling, scaffolding, fading, and coaching (Collins et al., 1991; Englert et al., 1991). These elements emphasize the importance of modeling that elaborates the cognitive and metacognitive aspects of problem-solving. "That is where cognitive apprenticeship is critical," these authors assert; "observing the processes by which an expert listener or reader thinks and practicing these skills under the guidance of the expert can teach students to learn on their own more skillfully" (Collins et al., 1991, p. 9). Cognitive apprenticeship provides access to an expert reader's strategies so that learners can emulate and develop these skills. The scaffolding element of cognitive apprenticeship includes decomposing a task into manageable elements that are presented in a logical sequence.

Another program of research along these lines, known as *reciprocal teaching* (Palincsar & Brown, 1984), includes elements similar to cognitive apprenticeship, such as modeling and scaffolding. In the first stage of reciprocal teaching, the teacher models the discussion facilitation role that students will soon be asked to assume. She formulates questions, makes predictions, summarizes, and clarifies difficulties with a text to demonstrate this process for students. Modeling and scaffolding serve to make explicit the cognitive and metacognitive strategies that guide her problem-solving choices, and fading gradually removes these supports once students gain access to the disciplinary content and practices that enable them to make appropriate problem-solving choices independently (Bransford et al., 2000; Collins et al., 1991; Englert et al., 1991; Palincsar & Brown, 1984). Teachers in this form of instruction “gradually release responsibility” (Purcell-Gates, Duke, & Stouffer, 2016, p. 1227) encouraging students to enact the learning strategies. Evidence on reciprocal teaching culled from nonexperimental studies has shown significant positive effects on students’ reading comprehension scores (Collins et al., 1991; Palincsar & Brown, 1984).

Englert and colleagues (1991) noted as well that few people learn writing skills and strategies on their own, so that writing as well as reading is implicated in such learning via these elements. The Cognitive Strategy Instruction in Writing (CSIW) program uses prompts to develop students' metacognitive knowledge about writing strategies (Englert et al., 1991). CSIW emphasizes teacher modeling of an inner dialogue for directing the writing process and includes *think sheets* designed to make the strategies, self-talk, and text structures of the writing process explicit to students. Use of the CSIW program in qualitative intervention research has been associated with improved expository writing and near transfer performance among students (Englert et al., 1991).

In mathematics, modeling may occur in the middle or even at the end of an instructional sequence. Contemporary standards for learning in mathematics, as we have seen, emphasize that students learn how to explain and justify their solutions to problems rather than just executing them. Various researchers have also supported this conceptualization of learning mathematics as a process of generating and justifying ideas rather than manipulating symbols (e.g., Ball, 1993a; Carpenter, Franke, & Levi, 2003; Walshaw & Anthony, 2008). Teachers working with the new standards model mathematical problem-solving to reinforce and extend student efforts to “construct viable arguments and critique the reasoning of others” (CCSS Initiative, 2015b, p. 6). NCTM’s (2000) *Principles and Standards for School Mathematics* also emphasizes developing students’ abilities to communicate with and about mathematics (Jackson & Cobb, 2010; NCTM, 2000; Stein, Smith, Henningsen, & Silver, 2000; Walshaw & Anthony, 2008).

One way of making the expectations for mathematical discourse explicit is for the teacher to model these disciplinary practices while explaining her reasoning. Sykes and Wilson (2015) emphasized the effectiveness of modeling a high level of performance for students. Teachers may engage directly in modeling to scaffold students’ efforts to model and explain their own processes and reasoning strategies (Collins et al., 1991; Duffy et al., 1988; Englert et al., 1991; Fisher & Frey, 2014; Schoenfeld, 1983).

A general tenet of this practice indicates that once teachers have focused students on a specific learning goal or goals, they must then maintain students' attention toward that goal throughout the instructional segment. The teacher's role is to coordinate the work so that students can develop their ideas while maintaining a thematic focus (Goldenberg, 1992) that helps to organize their progress. In one study, teachers' focus on meaning enabled significant development of students' mathematical reasoning (Khisty & Chval, 2002). Focusing on critical content and sequencing instruction logically are also key elements of explicit instruction, which has been associated with improved student outcomes (Brophy & Good, 1986; Gersten et al., 2000; Grossman et al., 2010).

Charalambous and colleagues (2011) reviewed literature by Leinhardt (1990, 2001), Leinhardt & Steele (2005), and others to outline a model of high-quality instructional explanations (see the Content and Structural Features subsections) that highlights the importance of making intermediate steps and decisions in a problem-solving process explicit to students and sharing steps and reasoning in a logical sequence. This latter feature of effective modeling draws attention to how teachers organize their presentation in a manner that proceeds logically from one element or aspect to the next, introducing this feature of effective modeling. When teachers jump from idea to idea, confuse steps in a reasoning process, or introduce explanations that do not cohere and build logically, this can disrupt student efforts at understanding and learning how to enact the cognitive and metacognitive strategies. Hence, as these scholars propose, logical sequencing of strategies and explanations is a critical feature of this construct.

Aspect 3: Narrating and Annotating the Demonstration of the Process, Strategy, or Technique

This dimension of the construct refers to the talk teachers employ as they are demonstrating the use of knowledge and skill. The demonstration itself is important, but equally so are the ways that teachers explain what they are doing as they are carrying out the target skill. This idea is easy to see with physical skills. When a swimming coach demonstrates the technique associated with a particular stroke, he explains the motion or narrates what he is doing and why that is efficient. Then he may also continue annotating his explanations as students are trying out the stroke for themselves. This idea, so fundamental to all kinds of instruction, applies to cognitive and metacognitive skills as well, including reading comprehension, writing strategies, mathematical problem-solving, development and support of arguments, monitoring and regulating of one's learning, and others. Annotating and narrating a demonstration with verbal and nonverbal markers to emphasize key concepts and connections is a research-based practice that promotes student understanding (Cartier, Smith, Stein, & Ross, 2013; Leinhardt, 1990, 2001; Schoenfeld, 1983; Smith & Stein, 2011).

Demonstrations make visible the work involved in solving a particular problem. In academic domains, this also requires externalizing cognitive work that is normally invisible (Collins et al., 1991; Duffy et al., 1988; Englert et al., 1991; Schoenfeld, 1983). Demonstrating while thinking aloud and modeling a high level of performance can boost student achievement (Collins et al., 1991; Englert et al., 1991; Fisher & Frey, 2014; Palincsar & Brown, 1984), especially if teachers provide sufficient context to enable students to decide when and how to use strategies independently.

The scholarly and research literature on this dimension of the MEC construct orients around a number of themes that include (a) how reasoning is modeled, (b) the role of modeling in promoting metacognitive strategies and learning, and (c) what constitutes high quality instructional explanations. We review these topics next.

Modeling and reasoning. Scholars have noted an important distinction here. Collins and colleagues (1991) contrasted modeling processes or procedures, on the one hand, and modeling thinking and reasoning, on the other. In a related study, Duffy and colleagues (1988) referred to the cognitive and metacognitive elements of modeling as *mental modeling*, but Collins and colleagues used the framework of *cognitive apprenticeship.* Cognitive modeling involves not only the procedure to solve a problem, but also discipline-specific concepts and reasoning processes that justify the application of the procedure. Metacognitive modeling also makes explicit *heuristic strategies*, or discipline-specific "rules of thumb" for approaching certain types of problems, and *control strategies*, which enable experts to organize the multiple lines of thinking involved in engaging with complex tasks (Collins et al., 1991). By sharing the reasoning and decision-making that supports the problem-solving process, the teacher connects processes with disciplinary knowledge—actions with ideas—and makes explicit to students the ways in which strategies and concepts interact in the problem-solving process.

Modeling and metacognition. An example of the importance of modeling metacognitive strategies is illustrated in Scardamalia and Bereiter's (1985, 1987) studies. Specifically, the authors described the naïve writing strategy of *knowledge telling*, a simple and sequential recitation of information as it occurs to the writer, and contrasted it with the more sophisticated strategy of *knowledge transforming*. Although novices may rely on knowledge-telling strategies, experts apply knowledge-transforming strategies to align the information and its presentation with the goals of the writing task. Knowledge-transforming strategies in writing include brainstorming, planning, organizing, drafting, evaluating, and revising pieces of writing (Scardamalia & Bereiter, 1985). Research has shown that poor writers employ few or none of these knowledge-transforming strategies (Englert et al., 1991; Gersten, Baker, Pugach, Scanlon, & Chard, 2001; Graham & Harris, 2003). Without explicit awareness of heuristic and control strategies, individuals must rely on knowledge-telling strategies that may or may not be well suited to the demands of a particular complex task.

These observations about writing apply more broadly. Experts transform knowledge in various fields by strategically choosing problem-solving approaches that are consistent with disciplinary standards and that efficiently organize multiple goals and contextual considerations of the work (Collins et al., 1991; Englert et al., 1991; Leinhardt, 1990, 2001; Scardamalia & Bereiter, 1985; Schoenfeld, 1985). As already noted, all students benefit from learning how to monitor and regulate their own learning (Ball, Hill, & Bass, 2005; Bransford et al., 2000; Duffy et al., 1988; Englert et al., 1991; Palincsar & Brown, 1984; Sykes & Wilson, 2015).

Theory, experience, and modest empirical evidence suggest that teachers' metacognitive commentary during instruction helps to emphasize key concepts and connect them to larger disciplinary concepts and learning goals (Leinhardt, 1990, 2001; Schoenfeld, 1983). Sharing reasoning and metacognitive cues is hypothesized to continuously clarify the purpose of the activities students are engaged with. Building conceptual connections among ideas in the classroom helps students understand relationships among disparate ideas and alternate perspectives (Leinhardt, 1993, 2001). Student understanding is promoted, this line of theorizing proposes, when teachers connect strategies with ideas (Cartier et al., 2013; Smith & Stein, 2011).

High-quality instructional explanations. A critical aspect of how teachers narrate and annotate demonstrations of knowledge and skill involves explanation. High-quality instructional explanations by teachers help students understand the reasoning behind the work and scaffold their abilities to construct their own explanations (Ball, 1993b; Collins et al., 1991; Jackson & Cobb, 2010; Leinhardt, 1990, 1993; Soter et al., 2008; Walshaw & Anthony, 2008). A number of investigators have explored this topic in depth.

Leinhardt (1990) suggested that an effective instructional explanation aims to “unpack” and examine the query or problem rather than merely stating it, thereby relying on a combination of deep disciplinary knowledge and solid pedagogical understanding. In her research, she posited four different types of explanation: common, disciplinary, self, and instructional. Among these, disciplinary explanations “serve the purpose of proving the legitimacy of new knowledge, reinterpretations of old knowledge, or challenges and answers to existing knowledge” (Leinhardt, 1990, p. 2). The author suggested that the nature of math and science lend themselves to more tightly constrained explanations, but disciplinary explanations in history or the humanities require consideration of the stance of the explainer. Achugar and Stainton (2010), referring to two of Leinhardt’s explanations, suggested that the goal of a history teacher is not to create new knowledge but to create new understanding in the learner, and as such, “teachers need to bridge the gap between the common explanations students come up with and the explanations valued by the disciplinary community” (p. 147).

Providing high-quality instructional explanations is an effective teaching practice that spans various academic disciplines (Charalambous et al., 2011; Collins et al., 1991; Duffy et al., 1988; Englert et al., 1991; Leinhardt, 1990, 1993, 2010). High-quality instructional explanations may be most critical at certain points in instruction, including introducing new content, responding to student questions, and helping students to understand their errors. Leinhardt (1990) defined instructional explanations as explanations “designed specifically for communication of a particular aspect of a subject matter knowledge they are designed to teach” that “convey, convince, and demonstrate, and . . . model explaining in the discipline and self-inquiry” (p. 4). Leinhardt (2010) subsequently clarified that “implicit assumptions need to be made explicit, connections between ideas need to be justified, representations need to be explicitly mapped, and the central query that guides the explanatory discussion must be identified” (p. 3) in instructional explanations. The emphasis on making each step explicit highlights the importance of verbal and nonverbal markers in identifying connections between smaller parts that compose the whole.

Based on a review of literature, Charalambous and colleagues (2011) highlighted eight additional criteria for high-quality instructional explanations:

- be meaningful and easy to understand;
- specify the question and show how to answer it;
- explain the thought process step-by-step without skipping steps;
- clarify transitions between steps;
- draw on and highlight key mathematical ideas;
- use appropriate language for the audience;
- define key terms and concepts appropriately; and
- use suitable examples and representations accurately.

Although high-quality instructional explanations promote student learning, incoherent or incomplete explanations can undermine the learning that is taking place (Ball, 1993a; Borko et al., 1992; Duke & Pearson, 2002; Leinhardt, 1990; Leinhardt & Steele, 2005; Rowland et al., 2003; Sykes & Wilson, 2015). To develop instructional explanations, teachers must take into account students' exposure to various ideas and current level of understanding, the norms or rules of disciplinary reasoning, and appropriate tools or devices to illustrate disciplinary concepts. Teachers make their own thinking and reasoning visible to show how reasoning unfolds in a subject area.

Soter and colleagues (2008) followed Webb's (1991) definition of an elaborated explanation as a "description of how things work, why some things are the way they are, and/or how to think about them" (Soter et al., p. 380). Studying video recordings of classroom discussions, the authors found that "longer teacher turns in the critical-analytic approaches [to classroom discussion] reflect teachers' attempts to model and scaffold more elaborated forms of reasoning so as to elicit this kind of talk from students" (Soter et al., 2008, p. 382). Discourse analyses of both student and teacher talk suggested that elaborated explanations promote high-level student comprehension, as judged by students' postintervention explanations. Soter et al. conjectured that this effect occurs by clarifying and reorganizing disciplinary content (thus making it more accessible to learners), developing new perspectives or approaches, and addressing misconceptions or gaps in understanding. Teacher modeling of elaborated explanations corresponded with a greater incidence of students sharing their own reasoning, which led the authors to conclude that “a certain amount of modeling and scaffolding on the part of the teacher is necessary to prompt elaborated forms of individual reasoning from students” (Soter et al., 2008, p. 389).

Studies also support the effectiveness of having students explain their interpretations and problem-solving processes (Cobb, Stephan, McClain, & Gravemeijer, 2001; Leinhardt, 1993; Leinhardt & Steele, 2005). Student explanations are critical to the learning goals expressed in the CCSS. As teachers elicit student explanations and interpretations, they participate by annotating students’ efforts and contributions, thereby amending, extending, and making connections across students and with the disciplinary content.

Aspect 4: Using Language, Terminology, and Representations

Academic language consists of the more formal, specialized lexicon of school and disciplinary scholarship, and it is contrasted with the less precise, informal social language used in everyday settings (Bailey & Butler, 2003). Research has supported the importance of introducing and developing academic language and in using multiple representations, examples, texts, and other tools to illustrate concepts and connect disciplinary ideas (Abedi & Lord, 2001; Bailey & Butler, 2003; Ball, 1993a; Butler & Castellon-Wellington, 2000; Leinhardt, 1990, 1993; Leinhardt & Steele, 2005; Pearson & Dole, 1987; Rowland et al., 2003).

For example, Beck and McKeown (2007) summarized an instructional intervention that used read-aloud texts to promote vocabulary acquisition among early elementary students. *Rich instruction*, a form of direct instruction, consists of explaining word meanings in accessible language, providing multiple examples in various contexts, and explicitly identifying and explaining appropriate and inappropriate uses of the new words in these varied contexts. An experimental test of the intervention found that elementary students learned significantly more words when taught via rich instruction than they did with traditional read-aloud instruction.

Studies have emphasized the importance of explicit instruction of literacy skills as well as the development of academic language (Bailey & Butler, 2003; Schleppegrell, 2013). A lack of academic language proficiency prevents students from demonstrating their knowledge in other subject areas (Abedi & Lord, 2001; Butler & Castellon-Wellington, 2000). Thus the development of academic language vocabulary is important not just for literacy achievement, but also for the way it affects students’ abilities to interact with disciplinary concepts and procedures in mathematics, science, and other subjects. Teachers introduce students to the discourse practices of various disciplines by attending carefully to the specialized language when naming and defining key concepts (Leinhardt, 1990, 1993). Disciplinary discourse practices include the rules and conventions for evidence, argumentation, and interpretation within a field of study—which are expressed, proposed, debated, and accepted in the context of the academic language of that field (Schwab, 1978).

Although introducing academic language is hypothesized to facilitate student learning (Abedi & Lord, 2001; Bailey & Butler, 2003; Butler & Castellon-Wellington, 2000), explanations of academic language must be anchored in language that is accessible and developmentally appropriate based on students' ages and prior experiences (Ball, 1993b; Ball, Hill, & Bass, 2005; Charalambous et al., 2011; Leinhardt, 1990; Leinhardt & Steele, 2005). Teachers must identify academic vocabulary and distinguish it from everyday language while adapting their own discourse to their students' current levels of language proficiency. If the language used to explain unfamiliar academic language is too advanced or complex for students, they will not be able to engage with new vocabulary or the disciplinary concepts they represent. Using clear and concise language and providing multiple examples and nonexamples are also key components of explicit instruction (Brophy & Good, 1986; Gersten et al., 2000; Swanson, 2001).

Leinhardt (1990) noted that "from an educational standpoint, it can be argued that one goal for students is to begin to approximate these disciplinary explanations in their own discussions within that subject" (p. 7). Teachers' explanations based on academic language and disciplinary standards for representation and reasoning develop students' abilities to generate their own high-quality explanations (Ball, 1993b; Collins et al., 1991; Leinhardt, 1990; Schoenfeld, 1983). Instructional explanations by teachers similarly model the format and elements of disciplinary explanations for students, while also responding "to an actual query, an anticipated or probable query, or perceived puzzlement" (Leinhardt, 1990, p. 9) to explain or extend classroom learning. What distinguishes the instructional explanation is its aim to "unpack" and examine the query or problem rather than merely stating it, which relies on a combination of deep disciplinary knowledge and solid pedagogical understanding. "Good instructional explanations also highlight appropriate metacognitive behaviors for thinking and working in a discipline (Leinhardt, 2001, 2010), thus forging both the substantive and the syntactic knowledge of the subject" (Charalambous et al., 2011, p. 442). Appropriate metacognitive behaviors on the part of teachers play a role in the development of *self-explanation inquiry*, a key aspect of students' abilities to coconstruct knowledge in a subject area (Leinhardt, 1990, p. 9).

Ball (1993a) introduced the concept of *representational contexts* as a means of framing thinking spaces for students to work on ideas. She discussed the importance of identifying appropriate language, conventions, and mental props that are accessible to students, build on what they already know, and support their engagement with new material. Although Ball acknowledged that these representational contexts are jointly created between teachers and students, she emphasized that teachers are ultimately responsible for "helping students develop *particular* ideas" (1993a, p. 174) about the content. Shulman (1986) also asserted that teachers need pedagogical content knowledge, including familiarity with the "the most powerful analogies, illustrations, explanations, and demonstrations—in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p. 9). To use representations as explanatory tools, teachers must select and develop multiple representations and examples that illustrate and connect disciplinary ideas and clarify their choices of representations and examples in various contexts (Ball, 1993a; Duke & Pearson, 2002; Kinach, 2002; Leinhardt, 1990; Rowland et al., 2003).

A representation or example that may emphasize and clarify disciplinary content in one context may introduce confusion or student misconceptions in another. For example, Ball (1993a) discussed how using electrical charges to explain negative numbers to sixth graders may rely on knowledge they do not possess, or how using such language as "borrowing" to describe subtraction can introduce confusions and misunderstandings of the concept. She emphasized that "the conventions, language, and stories that support the use of a given representational context are crucial to building valid understandings and connections" (Ball, 1993a, p. 164). Her work with prospective teachers suggested that their lack of deep mathematical knowledge inhibits their efforts to use representations with students; to compensate, prospective teachers rely on algorithms and rules they had memorized as students.

Rowland and colleagues (2003) explained that "the examples provided by a teacher ought, ideally, to be the outcome of a reflective process of choice, a deliberate and informed selection from the available options, some 'better' than others" (p. 243). Analyzing the representational examples of mathematical concepts used by 24 novice elementary teachers, the authors identified three common types of errors made in selecting mathematical representations: choosing instances that obscure the role of variables, choosing numbers to perform a certain arithmetic procedure when another procedure would be more sensible for those numbers, and using randomly generated examples when careful choices should be made. They suggested that, for example, the coordinate (1,1) is a poor choice for explaining geometric graphs because it obscures the role of variables by using the same value on both the x-axis and the y-axis (Rowland et al., 2003, p. 244).

In ELA, scholars recommend selecting texts that are well suited to the strategy being taught (e.g., Duke & Pearson, 2002). Duke and Pearson (2002) suggested that texts used to learn and practice a prediction strategy in reading comprehension, for example, should (a) be unfamiliar to students, (b) include a sequence of events, and (c) provide sufficient clues to enable novice readers to base predictions about what will happen next on textual evidence. A familiar text would be a poor choice because students may make accurate predictions from memory, circumventing rather than developing their skill in using this strategy.

These common errors may be attributed to the lack of explicit attention to choice and use of instructional explanations in mathematics teacher education programs (Zodik & Zaslavsky, 2008). These authors emphasized that, although many teachers plan their examples in advance, many examples are also created spontaneously, either in response to a student's comment or the realization that the preplanned example was not working as expected. These spontaneous examples draw on the teacher's content knowledge, where deeper content knowledge is hypothesized to yield richer examples. Drawing on disciplinary knowledge, teachers must select and use representations and examples that focus on central ideas, avoid distracting ideas, anticipate student difficulties, and model appropriate use of academic language (Leinhardt, 2001; Leinhardt & Steele, 2005; Rowland et al., 2003; Sykes & Wilson, 2015).

Prior Measurement of MEC

The dimensions of MEC just reviewed have been studied in various contexts and subject areas. In general, this research has been observational in nature and often characterized by small samples and inductive methods (e.g., Cobb et al., 2001; Collins et al., 1991; Engle, 2006; Engle et al., 2011; Englert et al., 1991; Khisty & Chval, 2002; Langer, 2001; Lubienski, 2002; Schleppegrell, 2013; Schoenfeld, 1983; Soter et al., 2008; Wharton-McDonald, Pressley, & Hampston, 1998). For example, Ball (e.g., 1993a, 1993b), Leinhardt (e.g., 1990, 1993), and

Leinhardt & Steele (2005) often described and analyzed cases from their experience in the field with instructional interventions in P–12 classrooms.

Most of the research has aimed at building and testing theory, in which the investigator examined one or a small number of cases in detail, relying on evidence supplied by some combination of structured and unstructured classroom observations, discourse analysis of videotaped segments of instruction, and postobservation interviews with teachers. Self-studies have also been used in which the investigator engaged in teaching, then explored the results based in student work, postlesson reflections, videotaped analysis, and others.

The program of reciprocal teaching developed by Palincsar and Brown (1984) amassed a relatively substantial body of evidence on the effectiveness of reciprocal teaching in various schooling contexts in which teachers were trained in the use of the instructional strategies. Similarly, studies of novice teacher learning in educator preparation programs (e.g., Borko et al., 1992; Charalambous et al., 2011; Rowland et al., 2003; Zodik & Zaslavsky, 2008) tended to make use of natural groupings of teacher candidates and to study a small number of candidates in detail.

Many of the findings are thus interpretations of patterns that emerged in observational data rather than “hard” outcome measures such as test scores. Some studies have looked across schools and/or used local, state, or nationally standardized assessments to determine the impact of particular practices on student achievement (e.g., Cohen, 2015; Grossman et al., 2014; Grossman et al., 2010; Langer, 2001) but have not included discrete measures of the instruction.

Although this construct, then, is richly theorized, its measurement has been largely qualitative, based on observations and case studies. An exception here is the measures employed in the studies of content knowledge for teaching. Here, paper-and-pencil selected and constructed response items have been developed, concentrating on elementary math and ELA (see Phelps, in press, for review and examples). And other studies along these lines have used video clips as stimuli to measure aspects of this construct (see Kersting, 2008; Kersting, Givvin, Thompson, Santagata, & Stigler, 2012).

Measurement Approach for MEC Performance Assessment

We next describe the central aspects of the measures used in the NOTE performance assessment of MEC together with rationales for these design choices. The types of tasks being developed to assess test takers' knowledge of and proficiency with the MEC construct are also reviewed.

Delivery Mode

Task types used to measure the MEC construct involve a virtual whiteboard interface with which teacher candidates interact via iPad. The virtual whiteboard includes various tools to help teacher candidates represent disciplinary content and practices during their performances. These include free drawing, text, highlighting, and erasing tools as well as preprogrammed electronic manipulatives (e.g., base 10 blocks in units, 10 strips, and flats of 100). Manipulatives, graphic organizers, and texts associated with various MEC tasks were selected because of their prevalence in the field and appropriateness for modeling and explaining the targeted content (e.g., although the teacher candidate is instructed to pace the presentation and use developmentally appropriate language, the candidate is also cautioned not to solicit input from hypothetical students). All of the content involved in the teacher candidate's modeling and explanation should be generated by the candidate to ensure that he or she is able to model and explain accurately and completely in this simplified context. Each teacher candidate will complete at least two MEC tasks, one in each content area (mathematics and ELA) and one at each grade-level band (lower elementary, Grades K–2; upper elementary, Grades 3–6). A teacher candidate who completes an upper elementary–level task in ELA will then complete a lower elementary task in mathematics.

Content

Each MEC task or item type is based on high-leverage content sampled from the CCSS (CCSS Initiative, 2015a, 2015b) and other national and state standards for ELA and mathematics (e.g., National Council of Teachers of English & International Reading Association, 2012; NCTM, 2000) in Grades 1–6. Tasks for the MEC assessment were developed in a collaborative and iterative fashion, with assessment development specialists at ETS working closely with postdoctoral fellows from TeachingWorks.

To support their efforts to select topics from the CCSS, ETS and TeachingWorks created heat maps that organize high-leverage content by subject area, subtopic, and grade level. The ELA heat map, for example, specifies four strands of academic content at each elementary grade level (K–6): reading, writing, speaking/listening, and language (CCSS Initiative, 2015a). The reading strand is further subdivided into foundational, informational, and literary reading competencies for elementary students.

Based on these analyses of the standards for learning, ETS and TeachingWorks identified content topics that are central to the discipline, prevalent in the P–12 curriculum, and suitable for assessment via teacher-led modeling. The released task in ELA, for example, focuses on modeling and explaining how to use context clues to figure out the meaning of unfamiliar words in informational texts; informational reading and language standards for lower elementary students are integrated in this task (CCSS Initiative, 2015a). An example of a MEC task for public release is included as the appendix. The selected high-leverage content topics were developed into tasks that direct teacher candidates to model and explain discipline-specific problem-solving strategies and reasoning for the implied audience of their performances: classroom students. Iterations of these tasks were improved by the participation of several dozen teacher candidates, who tried out the assessment tasks while being video-recorded during the early stages of task design. The assessment development teams and leadership reviewed the performances to identify ways in which each task was and was not eliciting desired behaviors from candidates; we also collected direct feedback from teacher candidates in the form of post-tryout surveys. This information was used iteratively to refine the assessment tasks. Feedback from performances and surveys also helped to formalize the organization of MEC task information into a task template that standardized the components and language across tasks to promote consistency and fairness.

Structural Features

For each MEC assessment, teacher candidates receive electronic copies of directions describing the grade level, content area, prep and assessment time, student learning goal, task description, and teaching context in the form of the assessment scenario and class background. Task directions also include student work samples and texts as appropriate to support the specified instructional segment of teacher-led modeling and explanation (e.g., Ball, 1993a; Duke & Pearson, 2002; Rowland et al., 2003; Zodik & Zaslavsky, 2008). Standardized language regarding the task, materials, and reminders for recording are included as well.

Based on these materials, teacher candidates have 20 minutes to plan and prepare an episode of MEC. Following the preparation period, teacher candidates have 7–10 minutes to perform the instructional segment while their voices are audio-recorded and the representations, texts, and annotations on the virtual whiteboard interface are video-recorded. Video-recording the sequence and delivery of each session with the candidate enables raters not only to see static copies of particular representations, but also how these are used and explained in the context of the instructional segment.

Scoring Criteria

Our approach to measuring the MEC construct focused on identifying the necessary elements of this practice by applying the MEC rubric (i.e., scoring rules). TeachingWorks and ETS collaborated iteratively on the development of the rubric, drawing on our combined expertise in teaching and learning together with data from trial performances to analyze, discuss, and agree on refinements to the MEC rubric. The rubric's main elements map onto the features of MEC identified in the literature as described above. An assumption underlying this rubric is that these are distinctive, recognizable dimensions of the construct that each contributes to an overall score. Based on pilot and field test data, this assumption will be tested and the rubric will be modified accordingly. The final scoring rubric will be made available on the ETS website. The rubric identifies these dimensions:

- framing the work;
- demonstrating the targeted process, strategy, or technique;
- narrating and annotating the demonstration of the process, strategy, or technique; and
- using language, terminology, and representations.

To clarify the critical elements of a successful MEC task performance and to support raters in scoring them reliably, ETS and TeachingWorks also collaborated in developing evidence inventories. Each MEC task has a corresponding evidence inventory that provides examples of the rubric-specified behaviors involved in completing that particular task. The evidence inventories are organized by the aspects of the rubric and list specific teaching behaviors, or moves, expected to accomplish each aspect. In some cases, the evidence inventory describes a range of appropriate ways to, for example, frame an instructional segment on multidigit subtraction with regrouping. In other cases, the performance expectation may be very specific. To take another example, if the task requires teacher candidates to model the "take away" approach to multidigit subtraction using the standard algorithm and prescribed numbers, the correct sequence of moves to illustrate and explain regrouping may be defined in more detail. By specifying performance expectations for making disciplinary content and practice explicit in terms of each task, the evidence inventories focus raters on particular moves that are directly observable rather than vague or idiosyncratic impressions. The evidence inventories thus are meant to support objective ratings of the teaching performance in which all candidates are held to the same clear standard of practice.

Limitations and Boundary Conditions

After candidates displayed and self-reported difficulties dealing with the absence of students, we added this direction in the preparation materials: "Although students in a real classroom might participate by asking questions and responding to prompts from the teacher, in this assessment all of the work should be done by you as the teacher. You should not call on or collect answers from hypothetical students while you teach. Speak in a tone, manner, and language that are grade appropriate." The direction addressed some teacher candidates' use of correct answers from hypothetical students to circumvent the modeling task (i.e., "The student is right, so content and practices don't require explanation"). Standardized language regarding the task, materials, and reminders for recording, in combination with example performances generated by TeachingWorks, yielded more accurate, complete, and thoughtful episodes of MEC by participating teacher candidates.

Nevertheless, the absence of students is a limitation for the MEC item type. This performance task focuses on how well the candidate represents the content. This restriction was made in order to concentrate measurement on how candidates managed to formulate and develop explanations, representations, and models of the content. This feature of instruction was judged by TeachingWorks to be of central importance, undergirding the claim that it is essential to making content explicit. This is not to deny that teachers interact with students over sequences of instruction in their intention of making content explicit. Rather, it is to claim that the skills measured with the MEC assessment are necessary, if insufficient, to the ways that teachers make content explicit.

This approach is consistent with recent calls from scholars (e.g., Grossman & McDonald, 2008; Jackson & Cobb, 2010) to engage pre- and in-service teachers in rehearsing components of their practice in less complex settings. The reduced complexity of a simulation—in this case concentrating just on the representation of content—can enable teacher candidates to focus on developing specific teaching-related skills in a low-stakes environment. Recent studies (e.g., Charalambous et al., 2011; Stecher et al., 2006) indicated that the decisions teachers make in simulated environments accurately reflect their performance in real-life situations.

Other limitations of this performance assessment include a constrained set of math manipulatives, selected for their prevalence in the literature and the field (e.g., Baroody, 1990; Clements, 1999; Fuson & Briars, 1990), and restrictions on the amount of text or size of numbers to meet requirements of space constraints. Similarly, the class background text in the MEC task design template indicates that students are "generally performing at grade level" and do not have special needs. Although this is not the case in every real-life classroom, the assessment task does not give teacher candidates enough time to differentiate instruction, nor is differentiation required in order to model and explain content in the simplified assessment setting.

Conclusion

Support for the MEC construct rests on advances in cognitive science, instructional design, and consensus views of good teaching. Transparency is important so that those affected by measurement understand and have confidence in the reasoning and the validity evidence that supports its measurement and use in high stakes decisions such as licensure. The intent of this paper is to contribute to this transparency by setting forth the research base and related evidence supporting the construct, together with the approach that ETS is taking to the measure of the construct for use in the NOTE assessment series.

Most noticeable in the ETS approach is a concentration on practice. Traditionally, licensure for teaching has involved tests of knowledge thought to underlie practice. The warrant is in the knowledge, with the assumption that the absence of such knowledge undercuts the claim to safe practice. This emphasis on knowledge makes good sense and is a feature in licensure for all professions and occupations. The NOTE assessment series continues this tradition with a substantial battery of knowledge measures that extend deeply into the use of such knowledge in the practice of teaching. Here, we further extend the warrant for licensure to direct measures of teaching practices themselves that we argue are central to teaching. The claim is not that these practices alone make up effective teaching, but rather that they are central and must be included. In all fields, the warrant for entry combines licensure assessments with the content of accredited programs, such that between them the full complement of knowledge and skill is conveyed and assessed. Working out the division of responsibility between licensure examinations and programs of preparation is a matter for professional judgment rendered by experts and stakeholders in a field of practice.

MEC meets the standard for centrality to effective teaching practice due to its consensus representation across many efforts to define good teaching. Such efforts have included research studies, observation instruments, accounts of best practice, teaching standards, and others. At the same time, the details associated with this construct matter and are under continuous negotiation as new knowledge accumulates, terms are redefined, new aspects are highlighted, and new evidence amassed. ETS intends to contribute to this ongoing conversation through its validity work on this construct. We invite readers to enter this conversation, recognizing that what is described here is neither the first word nor the last, but a contribution that sets a stake in the ground requiring at once robust defense and openness to new developments, new knowledge, and new challenges rising from the field of teaching research, policy, and practice.

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Appendix: Sample Released Task for Modeling and Explaining Content (MEC)

This task is part of an assessment designed to collect evidence of a prospective teacher's ability to model and explain content. Each task in the assessment is designed to focus on a specific high-leverage content topic in mathematics or English language arts (ELA) at the elementary level.

High-Leverage Practice: Modeling and Explaining Content

Teachers strategically model and explain content to give their students access to the core ideas and processes of the content being modeled. As a result, students develop their ability to use the process, strategy, or technique independently. Successful modeling and explaining includes the following.

1. Introducing and summarizing the process, strategy, or technique. The teacher frames the segment of instruction by naming the content and explaining its purpose. At the closing, the teacher revisits the purpose of the process, strategy, or technique and summarizes the key ideas used to perform the work.

2. Demonstrating the process, strategy, or technique used to perform the work. The teacher demonstrates this work by verbally explaining it and by creating a visual record.

3. Making visible and highlighting the reasoning and decision-making integral to the work while performing it. While demonstrating the process, strategy, or technique, the teacher simultaneously annotates and narrates the reasoning and decision-making through the use of verbal markers and emphasizing the key ideas.

Overview

Part 1: Preparation for performance. You will have a maximum of 20 minutes of preparation time. A timer will start when you begin your preparation; however, you do not need to use all of the time. Practicing while you prepare is recommended. You may practice with the materials on the Teacher Materials pages and on the Classroom Materials pages.

Part 2: A recorded performance. You will have a maximum of 10 minutes to model and explain a process, strategy, or technique. A timer will start when you begin your performance; however, you do not need to use all of the time. You should monitor the timer to ensure that you have enough time to model and explain the process, strategy, or technique and to conclude.

Scoring Information

Your performance on the assessment task will be evaluated on the following criteria.

- Your ability to introduce and summarize the process, strategy, or technique
- Your ability to demonstrate the process, strategy, or technique to perform the work
- Your ability to make visible and highlight the reasoning and decision-making integral to the work while performing it

- Your ability to use effective representations and developmentally-appropriate language and terminology

General Instructions

Preparation:

* The task information will be presented in two tabs: Teacher Materials and Classroom Materials.

- The Teacher Materials tab will include information you will use when you prepare: Intro, Directions, and Notes. You can mark up and/or make notes on any of these pages during your 20 minutes of preparation time.
- The Classroom Materials tab will be used during your performance. It includes: Performance Materials and Whiteboard. During your 20 minutes of preparation time, you may practice with the touch screen, and you may set up the space on the Performance Materials and Whiteboard pages, as appropriate for this task.

* You may also take notes on the scratch paper provided. All scratch paper will be collected at the end of the task.

* You may refer to all preparation materials during your performance.

* Practicing while you prepare is recommended.

* Although students in a real classroom might participate by asking questions and responding to prompts from the teacher, in this assessment all of the work should be done by you as the teacher. You should not call on or collect answers from hypothetical students while you teach.

* You do not need to use all of the preparation time. When you are finished with your preparation, make sure to erase or clear anything you do not want to appear on the Performance Materials and Whiteboard pages at the beginning of your performance. Then tell the proctor that you are ready to begin your performance.

Performance:

* When the proctor tells you to begin the performance, say, “Begin performance,” and then read your participant ID number.

* When you write on any of the Classroom Materials pages, write as you would if you were teaching a class of students. Your writing and representations should be legible and age-appropriate for the task.

* Use a tone, manner, and vocabulary that are grade appropriate.

* You do NOT need to use all of the time allowed for the performance. When you are finished, say, “End performance,” and notify the proctor that you are finished.

Task Directions:

Grade level: Second grade

Content area: English language arts

Student learning goal: Students will understand how to use context clues to determine the meaning of unfamiliar words.

Your task: Model and explain how to use context clues to determine the meaning of the following unfamiliar words from the text: *prowled* and *prey*.

Materials: An informational text about dinosaurs which includes the two words that you will use to model: *prowled* and *prey*. This text is available on the Performance Materials page.

What is the scenario?

The students in this second-grade class are generally performing at grade level. You recognize that the students are improving their decoding skills steadily but that they are encountering unfamiliar vocabulary that is affecting their overall comprehension. You have decided to model how to use context clues to determine the meaning of unfamiliar words. By making your thinking visible, you will begin to help students understand how to use context clues to determine the meaning of unfamiliar words.

What will you do?

In this task, you will model how to use context clues to determine the meaning of unfamiliar words. You will use the provided informational text to model the use of context clues to determine the meaning of the following words: *prowled* and *prey*. You should briefly frame this segment of instruction by naming the process, strategy, or technique and explaining its purpose. You should revisit the name and purpose of the process, strategy, or technique in your closing statement. You should do the following.

- Explain how and when to use context clues and why they are important for readers to use.
- Model how you, as a reader, acknowledge when you have come to an unfamiliar word and recognize that you will need to determine its meaning.
- Model how to use context clues to help you determine meaning.
- Explain the process as you would for a group of second graders. Be sure to narrate your thinking and make your decision-making explicit as you use context clues to determine the meaning of unfamiliar words.

What text will you use?

Some dinosaurs ate small plants.
Others that were meat-eaters, like

Tyrannosaurus Rex, prowled for food.
They crept through the trees as they
hunted prey, looking for other animals
to eat.

Task Directions

Grade level: Third grade

Content area: Mathematics

Student learning goal: Students will understand the meaning of the steps in the traditional addition algorithm by representing multidigit addition problems with base 10 blocks.

Your task: Model the traditional addition algorithm and simultaneously use base 10 blocks to show how to solve 275 + 143.

Materials: A set of virtual base ten blocks, available on the Performance Materials page, which can be moved onto, off of, and around the workspace

What is the scenario?

The students in this third-grade class are generally performing at grade level. You have been working with them on multidigit addition. They have a solid understanding of regrouping when using base 10 blocks but are struggling with the connection to the standard algorithm. Specifically, you have noticed that they have trouble understanding the meaning of the numbers that they record in the standard algorithm. You are going to instruct them on how to use base 10 blocks to illustrate the meaning of the steps of the traditional addition algorithm to solve the multidigit problem 275 + 143.

What will you do?

In this task, you will explain how to solve a multidigit addition problem, 275 + 143, that requires regrouping. You will do this by showing the connection between the standard addition algorithm and the base 10 blocks. Specifically, you will use the language associated with base 10 blocks and the standard algorithm to explain how to solve the problem. You should briefly frame this segment of instruction by naming the process, strategy, or technique and explaining its purpose. You should revisit the name and purpose of the process, strategy, or technique in your closing statement. You should do the following.

- Model how to solve the problem using the traditional addition algorithm.
- Simultaneously show how the addition algorithm connects to the problem using base ten blocks to illustrate the meaning of each step.
- Explain the process as you would for a group of third graders. Be sure to narrate your thinking and make your decision-making explicit to ensure that your students could use the process for solving a multidigit addition problem that requires regrouping

Notes

[1] The NOTE assessment series involves three performance assessments: Leading a Classroom Discussion, Eliciting Student Thinking, and Modeling and Explaining Content.