CONNECTING TEACHING AND LEARNING IN CURRICULUM ADAPTATIONS

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This study of six teachers focuses on the ways they organized the classroom discourse, attended to student thinking, and adapted complex tasks from a Standard-based middle school curriculum. The study explores Cohen's (2011) premise that the knowledge teachers develop is related to their attentiveness to student teaching. This study explores the relationship between the extent to which teachers were successfully able to elicit and organize instruction around student strategies and their ability to productively adapt tasks in terms of being responsive and maintaining cognitive demand. The results show that teachers with the most student-centered discourse practices were also able to provide the most detailed justifications for task adaptations and to productively adapt tasks from the Connected Mathematics Program (CMP) curriculum.

Keywords: Instructional activities and practices, Classroom Discourse

The ways teachers attend to student thinking impacts the kinds of knowledge they are likely to develop. This poses a significant change for teacher educators, as Cohen (2011) notes that most instruction "is marked by little close attention to learners' thinking and little effort to design instruction to advance it" (p. 27). Cohen attributes the rareness of attending to student thinking to the inherent uncertainty associated with listening and responding to another person's thinking, in contrast to the relative certainty and predictability of helping students to practice and remember predefined and narrow forms of knowledge. However, teachers' attention to how students make sense of mathematical concepts is, as Cohen notes, central to *attentive* teaching. Furthermore, Confrey et al. (2008) state that attentive teaching is an essential practice with respect to using the curriculum programs aligned with the National Council of Teachers of Mathematics (NCTM) Standards documents (NCTM, 1989, 1991) [hereafter referred to *Standards-based curriculum programs*]. Given the large U.S. investment in the Standards-based programs, it is imperative to research practices that lead to productive uses of the materials.

Cohen (2011)'s essential premise is that teaching needs to be connected with student learning to be effective. That is, teachers need to pay attention to how their teaching practices influence how students reason about academic content. He analyzes the relationship between teaching and learning by exploring connections between the knowledge developed by teachers, the organization of the classroom discourse, and the ways teachers attend to student thinking. He describes how teachers who engage in more expansive forms of discourse have opportunities to develop a greater sense of how students reason about content and can extend student learning to more complex forms of knowledge than would otherwise be the case, stating that "teachers who attend only a little or narrowly to students' knowledge constrain their opportunities to make intellectual connections that may advance learning" (p. 39).

The connections between teachers' discourse practices, their attention to student thinking, and their use of Standards-based curriculum materials are poorly understood. Most of the research on Standards-based materials focuses on early stages of implementation, which has limited the ability to show the longer term impact of teachers' instructional practices on their understanding of how the materials engage students. In short, Cohen's (2011) basic premise is

largely conjectural with respect to teachers' understanding and use of Standards-based programs. Consequently, this study explores Cohen's conjecture that there is a connection between teachers' discourse practices, their attention to student thinking, and the ways they design instruction to intentionally provoke forms of student learning. The study focuses on the ways that teachers' attention to student thinking is not only helpful in the moment but is associated with more productive uses of the materials over time. The study is set in the context in which an NSF-funded middle school curriculum was implemented, building from the idea, as Confrey et al. (2008) note, that Standards-based programs were designed to be sensitive to the ways teachers build instruction around student thinking.

Curriculum Adaptations

Adaptations to tasks as represented in written materials are inevitable as they are transformed in dynamic classroom contexts (Remillard, 2005). Spontaneous adaptations – those that happen during enactment – are influenced by the teacher's ability to purposefully improvise on the fly, which has been shown to be a high-capacity practice. In this study, the focus is on adaptations to curriculum materials that occur prior to enactment, as teachers use and adapt written materials to plan lessons (Remillard, 1999; Stein, Grover & Henningsen, 1996). In these planned adaptations, teachers often tinker with written tasks in ways that are intended to improve the efficiency with which students are able to complete tasks, but which neglect the conceptual development of the lesson (Kennedy, 2005). Other adaptations are in response to constraints in the local context, often in ways geared toward easing the chCorwinges and logistical burdens of cognitively demanding tasks (Arbaugh, Lannin, Jones, & Park-Rogers., 2006; Keiser & Lambdin, 1996; Manouchehri & Goodman, 1998). Typically adaptations lower the cognitive demand of tasks by removing their ambiguous or difficult features (Doyle & Carter, 1998; Stein, Grover, & Henningsen), though teachers have been shown to adapt tasks spontaneously in ways that build on students' contributions and maintain task complexity (e.g., Lampert, 2001). Recent work in mathematics and science education has described teachers who make adaptations to tasks that are productive, in that they maintain coherence with the design of the curriculum, they maintain the cognitive demand of tasks, and they are responsive to the classroom context (Author, 2009, 2011; Author, in press; Brown & Edelson, 2003; Drake & Sherin, 2009; Roth McDuffie & Mather, 2009).

Methods
The Connected Mathematics Project Curriculum Materials

The Connected Mathematics Project (CMP) materials (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006) emphasize student exploration in chCorwinging tasks as a means of developing mathematical content and they are comprised largely of tasks that are designed to be implemented at a high level of cognitive demand. Tasks in CMP also frequently require substantial amounts of student justification and explanation. Each CMP unit is divided into four to five *investigations*, each of which consists of a task situation or context that serves to organize the investigation. Each investigation begins with an initial problem that focuses on the key mathematical concepts, followed by a number of related problems. The investigations are intended to follow a *launch-explore-summarize* sequence. The launch portion serves to familiarize students with the context and the mathematics as a means of priming student activity in the subsequent exploration, in which students engage with a task that can typically be approached in multiple ways. The summarize portion allows for various solutions to be

compared and for the teacher to emphasize the important mathematical aspects of the tasks (Lappan, Fey, Fitzgerald, Friel, & Phillips., 2004). An important feature of the CMP materials is that mathematical concepts are developed across a sequence of tasks, lending coherence that is typically lacking in U.S. curriculum materials.

The Teachers

The six teachers were selected from a larger video sample. Five of the six teachers had extensive experience with CMP, having used the curriculum materials for a span of five or more years, and all had attended multiple week-long curriculum-specific professional development institutes. The sixth teacher was in her second year of using CMP and had attended a number of professional development workshops, including a week-long institute in Michigan. Two of these four teachers, Audin and Baldeck, were a 6th grade planning team, and the other three, Corwin, Knauff, and Walsh, were an 8th grade planning team, though Corwin was only a part of the team for the school year in which she participated in the study. The sixth teacher, Durst, taught 7th grade in Lakeville, a larger suburban district whose students typically scored lower than those in Brookline and who came from a greater diversity of socioeconomic backgrounds. All six teachers made minimal omissions to the CMP instructional sequences for which they were observed, rarely (if at all) supplemented with new activities. Furthermore, with minimal exceptions, the teachers followed the three-part format for each investigation, as recommended in the teacher resource materials. See Table 1 for a listing of the teachers, their grades, and the units in which they were observed teaching.

Table 1: Teacher, Grades, and Units in Which They Were Observed

Teacher	Grade	Units
Audin	6	Accentuate the Negative, Comparing and Scaling
Baldeck	6	Accentuate the Negative, Comparing and Scaling
Corwin	8	Moving Straight Ahead
Knauff	8	Say It With Symbols
Walsh	8	Say It With Symbols
Durst	7	Comparing and Scaling

Data Collection

The research team created *Unit Sets*, modifying the *teaching set* methodology (Cobb, Zhao, & Dean, 2009), which involves videotaping multiple lessons and using specific events or practices observed in those lessons as the basis of teacher interviews. The pre-unit interviews focused on a teachers' perceptions of the main instructional goals for the unit, the primary chCorwinges they anticipated in terms of enacting the instructional sequences in the unit, and the key tasks and representations that facilitated the learning trajectories within the instructional sequences. The video-stimulated interviews were based on a set of about 10 episodes, ranging from three to 15 minutes in length, selected by the researcher to provoke reflection about instructional sequences in the unit. The researchers generated a series of specific questions around each clip and compiled the questions and the video clips, which was provided to the teacher. The teacher then had an opportunity to preview the clips (usually a week), after which they were interviewed for 60-90 minutes.

Analysis of Task Adaptations

Planned adaptations are characterized in the study by the extent to which they align with the philosophy of the curriculum program, maintain or enhance the cognitive demand and

complexity of tasks, are justified by observations of how students interact with the materials, and ultimately how they provide opportunities for students to engage in mathematical practices. The cognitive demand of tasks was determined by the extent to which ambiguity regarding choice of strategy was maintained and by the extent to which the task emphasized connections to underlying mathematical concepts. For example, if a teacher provided explicit instructions beyond what was in the student text about how to complete a task, it was deemed an adaptation that reduced demand. Conversely, if the adaptation facilitated strategies that became to focus of whole-class discussions in ways that emphasized concepts, it was deemed an adaptation that maintained or enhanced demand. The justifications for adaptations were characterized by the extent to which teachers provided detailed accounts from past enactments to justify their adaptations or whether they simply evaluated a past enactment (i.e., "I tried the task as written in the materials, it didn't go well, so I changed it"). The adaptations were usually identified in the observations of the video data, which gave the interviewer the opportunity to question the teacher about the adaptation and rationale for the adaptation.

Analysis of Classroom Discourse

Building from research on Accountable Talk (Michaels, O'Connor, & Resnick, 2008), the project team separated the teacher discourse codes into two categories that highlighted different ways that teachers attended publicly to student thinking, *teacher probes of students*, and *teacher moves that highlight strategies*. In addition, there was a code for *student explanations*, which was used when students' contributions included evidence to support the steps used to arrive at an answer. The three codes in the *teacher probes* category included *probed student to explain reasoning*, *probed students to confirm/ clarify*, and *elicited comments on strategy*. The *probed student to explain reasoning* code was applied when the teacher asked a student why he or she approached a problem a certain way or asked for justification of a procedure. The *probed students to confirm/ clarify* code was used when the teacher asked a student to confirm if the teacher's stated interpretation of the student' strategy was accurate or when the teacher sought clarification of part of the student's strategy. The *elicited comment on student strategy* code was used when the teacher asked other students what they thought of a particular strategy. The three codes in the *teacher moves that highlight strategies* category include *recalled past strategy*, *expanded on student response*, and *displayed student strategy*. The *recalled past strategy* code was used when the teacher introduced a strategy that had been presented at a minimum of several exchanges earlier and sometimes from much earlier in the lesson. The *expanded on student response* strategy was used when the teacher's recounting of a strategy included new terminology or steps. The *displayed student strategy* was used whenever the teacher publicly displayed a strategy, either by projecting the student's work or by rewriting the strategy on the board.

Results

The Classroom Discourse

The evidence of student engagement was characterized by the frequency with which teachers displayed student strategies. Each teacher displayed student strategies in a third or more of the time, either by displaying the students' version of the strategy on poster paper or projecting it, or by rewriting key steps of the strategy on the board or overhead. These strategies were then discussed, either by the students or, more commonly, by the teacher, usually to highlight a particular concept or procedure. There were substantive differences in the frequency with which students provided explanations for the strategies. Similarly, there were differences in the ways

the teachers elicited explanations associated with student strategies, and in the ways teachers called attention to and organized discussion around student strategies, as shown in Table 2.

There were big differences in the extent to which students offered explanations for their strategies. Audin's and Baldeck's students contributed explanations substantially more often than the students of the other four teachers (two to fifteen times as often). The results in Table 2 show that teacher moves in the category of *teacher probed students* all were strongly associated with the frequency with which students provided explanations, which suggests that these moves were helpful in eliciting student explanations. In these instances the teacher explicitly asked students to provide evidence for their strategies beyond simply describing steps. Similarly, moves coded as *probed student to confirm/ clarify* frequently elicited warrants that were coded as explanations. Moves coded as *elicited comments on strategy* were strongly associated with the probing moves in terms of their frequencies, which might explain the association between the *elicited comments* code and student explanations.

The other teacher move highly associated with student explanations was *teacher recalled past strategy*. This move was used more frequently by Audin and Baldeck and thus its association with student explanations may be confounded with the probing moves. However, this code represents a slightly different phenomenon and stands in contrast with the *teacher expanded student response* code, which also involved teachers broadcasting or explaining a student response or strategy, but which was poorly associated with student explanations. In moves coded as *recalled past strategy*, the teacher re-introduced a strategy that had been presented earlier in the lesson. In this move, the teacher typically highlighted the mathematical features of a strategy or showed how different strategies were related. The temporal distance between the presentation of the student explanation and the teacher recall of that explanation stands in contrast with the more temporally proximate teacher moves coded as *expanded on a student response*, which typically immediately followed a student response and functioned to evaluate and revise that response. The *recalled strategy* showed how the teacher connected student explanations over time and used student explanations strategically to emphasize key mathematical points.

Table 2: Discourse Practices

	Student explanations	Teacher probes of students			Teacher moves that highlight strategies		
		Probed to explain reasoning	Probed to confirm/ clarify	Elicited comments on strategy	Recalled past strategy	Expanded on student strategy	Publicly displayed strategy
Audin	60%[*]	19%	17%	35%	9%	12%	52%
Baldeck	39%	16%	21%	30%	5%	29%	65%
Corwin	14%	11%	7%	14%	3%	6%	51%
Durst	12%	2%	9%	8%	3%	29%	41%
Walsh	10%	5%	0%	2%	2%	7%	47%
Knauff	4%	0%	6%	2%	0%	23%	37%

[*]The percentages refer to the number of one-minute segments a code appeared relative to the total number of one-minute segments for that teacher

The *teacher expanded student response* moves provides insight into the differences between the teachers in terms of how they focused discussion on student strategies, especially the four

Martinez, M. & Castro Superfine, A (Eds.). (2013). *Proceedings of the 35th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Chicago, IL: University of Illinois at Chicago.

teachers who most frequently deployed the move. When Durst or Knauff expanded on a student's explanation, they tended to 'hijack' the strategy, explaining it without seeking student input. A third teacher, Baldeck, especially in Comparing and Scaling, discussed the strategies as if she was the student, explaining the mathematics but doing so as if she was recounting the student's thought processes, particularly for unusual strategies in the Orange Juice task. The expansions of the fourth teacher, Audin's, involved adding terminology or concepts to the discussion.

Curriculum Adaptations

There were differences in the extent to which the task adaptations maintained cognitive demand, differences that were associated with the nature of the evidence used to justify the adaptations. In general, those adaptations that maintained cognitive demand were justified by detailed evidence from past adaptations, as noted in Table 3. Audin and Baldeck adapted 16 tasks, of which 11 were determined to have maintained or enhanced the cognitive demand of the tasks. For example, in a unit on integer addition and subtraction, the adaptations focused student attention on connections between various representations, between operations on integers and the absolute values of the integers, and on the connections between student strategies. For example, one adaptation involved having students record and compare the conjectures that emerged from the introductory tasks to the unit. The teachers helped to guide discussions around the conjectures toward recognizing patterns involving addition and subtraction of integers and the underlying operations related to a number's distance from zero (absolute was not yet formalized), with the ultimate goal of building toward establishing sensible and efficient algorithms.

Table 3: Planned Adaptations

	Number of notable adaptations	Impact on cognitive demand/ coherence with design	Nature of evidence for adaptation
Audin	Six	Five maintained or enhanced demand	Five were justified by detailed accounts from past enactments
Baldeck	Ten	Eight maintained or enhanced demand	Six adaptations were justified by detailed accounts from past enactments; four justified by minimal evidence
Corwin	Four	One maintained demand	Justified by minimal evidence or evaluation of students' ability
Durst	Three	All reduced demand	Justified by minimal evidence or evaluation of students' ability
Knauff	Two	All reduced demand	Justified by minimal evidence or evaluation of students' ability
Walsh	Four	All reduced demand	Justified by minimal evidence or evaluation of students' ability

For the other four teachers, only one of the 13 noted adaptations were determined to have maintained or enhance the cognitive demand, while the other 12 reduced the demand of the tasks. In most cases, the reduction in demand resulted from providing explicit procedures to complete the task or from breaking the task into smaller parts, reducing the ambiguity and opportunity to make connections.

Discussion

There was a strong association between eliciting and successfully organizing discussions around student strategies and the tendency to adapt tasks in ways that maintained the cognitive demand of the tasks. Furthermore, the teachers who adapted tasks productively (maintained demand) cited details of student thinking from past enactments to justify those adaptations. A possible explanation for this finding is that teachers with strong mathematical and pedagogical knowledge can facilitate productive discussions as well as productively adapt curriculum materials. While this is plausible, it is important to note that Audin and Baldeck rarely adapted tasks in the initial implementations of the tasks. On average, the adaptations were designed in the third year they implemented the tasks. Both Audin and Baldeck have discussion intensive classes, as indicated in Table 2. In addition to the data presented in Table 2, the practices of these teachers have been observed over a seven-year span and during that time their classroom discourse practices have consistently focused on student thinking. The data in Table 1 indicate two prominent traits for Audin and Baldeck, the teachers who were most able to elicit student explanations: they persistently probed students' thinking, and they more strategically expanded and recalled student strategies to maintain a coherent mathematical thread in the discussion.

The data suggest that a consistent focus on student thinking, as evidenced by the frequency with which students provided explanations, provides opportunities for teachers to develop a deep understanding of how students engage with mathematical ideas in the enactments of demanding tasks. Furthermore, these opportunities translate into productive adaptations by providing a rationale for deciding when to revise a task as well as guidance for how to revise it. The teachers in whose classes the students less frequently provided explanations often decided to revise a task based on the evaluation that the students could not complete it successfully rather than on a more detailed rationale; in those cases, there was little explanation as to why the adaptation would more successfully engage students with mathematical ideas. Instead, the goal was to make it more likely that the students could complete each part of the task, often in isolation of the other parts.

The results of this study have implications for mathematics educators and for districts who adopt Standards-based programs with the goal of transforming instruction. First, discourse practices play a role for teacher learning by providing opportunities for attentive teaching. These discourse practices include not only persistent efforts to probe student reasoning but also skillful expansion and recall of those strategies to make important connections. However, it is the probing practices that open up the opportunities to learn about student thinking and consequently provide objects for teacher attention.

A second implication is that without explicit attempts by teachers to connect their teaching practices to the ways student engage with mathematical ideas, it appears unlikely that teachers will adapt the materials productively. The teachers in this study who primarily evaluated whether students were able to successfully complete a task were also the ones whose adaptations primarily lowered the cognitive demands of the tasks. These teachers did little to elicit and probe student thinking, and consequently had little evidence on which to guide subsequent adaptations of the materials.

The third implication is that the teachers who engaged in the most complex enactments in terms of eliciting and building from student thinking were also able to productively adapt the tasks. This required a messier and more uncertain environment as the teachers needed to productively guide classroom discussions even as they interpreted student strategies and attempted to engage students in interpreting their peer's strategies. At times this was

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cumbersome and slower-paced than the classrooms of the other four teachers and created some concerns about content coverage.

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