Characterizing the Tasks Involved in Teachers' Use of Curriculum

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Introduction

As members of a research team working to explore the ways in which teachers use curricular materials and capacities they need for effective curriculum use, we participated in the development of an instrument to assess teachers' knowledge to identify the mathematical concepts and connections contained within excerpts from five different elementary mathematics curriculum programs (see the paper, *Conceptualizing and Assessing Curriculum Embedded Mathematics Knowledge*, in this session). One prerequisite to the creation of this instrument was a conceptual framework on which to base our work. An appropriate framework was not present in the literature, so we set about developing one. We drew from literature involving related knowledge typologies that have been significantly conceptualized by other scholars, especially the work regarding the mathematical knowledge needed for teaching [MKT] (Ball, Thames, and Phelps, 2008). The theoretical background developed in this field of research, however, was not sufficient for developing a framework of teachers' understanding of the mathematics embedded in curricular materials. In order to adequately identify the unique components that make up a teacher's understanding of the mathematics in curricular materials, we required an understanding of the types of tasks teachers engage in while planning lessons. This study aims to characterize these tasks from empirical data.

We interviewed math teachers using a protocol designed to gain insight into the ways in which teachers understand the mathematics within the curriculum materials they read and how this understanding relates to the way they plan future lessons. Through the presentation of our findings and the subsequent analysis, we construct the beginnings of a framework for understanding what teachers do as they use curricular materials prior to class and the knowledge they draw upon during the process. The purposes of this framework are two-fold. First, this work informed the development of the Curriculum Embedded Mathematics Assessment (CEMA) to measure teachers' understanding of the mathematics embedded in curricular materials. Furthermore, we hope that this framework will contribute to a fuller understanding of the way teachers' understanding of curricular materials relates to MKT.

Review of the Literature

A great deal of progress has been made towards conceptualizing the types of knowledge needed for teaching. Shulman (1986), in an address meant to complicate the existing assumptions about the types of knowledge that are necessary for teaching, identified research on subject matter understanding of teachers as the "missing paradigm" in education research. He suggested three categories of content knowledge needed for teaching: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. Subject matter content knowledge, he argued, includes both substantive knowledge (understanding the way the facts are organized) and syntactic knowledge (understanding of the way knowledge is discovered and verified) of the discipline. While these categories have since been taken up by other authors, the most noteworthy portion of his address involved the identification and naming of a separate type of knowledge needed for teaching that he called *pedagogical content knowledge*. Familiarity with the various possible representations of the subject matter and the ways students can understand or misunderstand content weigh heavily in his definition of the term:

> Within the category of pedagogical content knowledge I include, for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations-in a word, the ways of representing and formulating the subject that make it comprehensible to others… Pedagogical

> content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. (p. 9)

He then defined a third category of content knowledge, *curricular knowledge*, which involves awareness of the curricular programs available for a given topic and grade level, as well as the affordances and constraints of each. Also included in this category is knowledge of the content that is taught prior to and further on in students' education.

In the years following Shulman's address, researchers have taken up the idea of pedagogical content knowledge in a variety of ways. Ball, Thames, and Phelps (2008) attempt to answer Shulman's charge to clarify the types of mathematical knowledge required for teaching by identifying and describing a construct they call *mathematical knowledge for teaching* (MKT), composed of the two domains pertaining to mathematical subject area knowledge in Shulman's address. In the framework proposed by Ball et al. (2008), the first domain, *subject matter knowledge*, includes specialized content knowledge that is specific to teaching and teachers, common content knowledge that is used across professions, and horizon content knowledge that involves the math that students will encounter in future mathematics classes. The second domain, *pedagogical content knowledge*, is composed of three subdomains. Knowledge of content and students involves awareness of the conceptions and misconceptions students frequently have regarding specific math topics, as well as the ability to predict how students will understand and react to various tasks. Knowledge of content and teaching is what teachers draw upon when deciding between possible ways to represent mathematical ideas and how to sequence lessons. Provisionally, Ball et al. place Shulman's curricular knowledge category within the pedagogical content knowledge domain, calling this knowledge of content and curriculum. However, they assert their lack of certainty regarding this placement, arguing that alternatively, this form of knowledge may fit within the knowledge of content and teaching category or overlap across a number of domains.

The work of Ball et al. is significant to this study for two reasons. First, they make clear the fact that an understanding of how teachers' knowledge of mathematics in curriculum remains nebulous. Secondly, our study is informed by the types of questions that guide their research on mathematical knowledge for teaching. Specifically, Ball et al. (2008) attempt to answer two questions in order to clarify the details of this construct:

1. What are the recurrent tasks and problems of teaching mathematics? What do teachers do as they teach mathematics?
2. What mathematical knowledge, skills, and sensibilities are required to manage these tasks? (p. 395)

We modified these questions slightly to develop our own research questions that deal specifically with teachers' use of curricular materials. In this study, we ask, (1) *what are the recurrent tasks teachers engage in as they use mathematics curricular materials while planning?* and (2) *what types of knowledge, skills, and sensibilities are required to manage these tasks?*

A number of authors have written about the ways teachers interact with curriculum (see Remillard, 2005). Remillard (1999) provides insight into how teachers interact with the written curriculum to design a lesson plan for use during enactment in the classroom. She describes differences in the ways two elementary school teachers read the teachers' guide, select tasks in recognition of their particular classroom contexts, then adapt the tasks during the lesson in reaction to the events in the classroom. Notably, Remillard found that neither teacher relied heavily on the published curriculum materials during the phase in which the curriculum was enacted and adapted during enactment.

Brown (2009) offers another perspective on the topic, describing teachers' use of curriculum as design and the written curriculum as a tool aiding design process. He proposes a framework for analyzing the degree to which teachers appropriate the written curricula when planning lessons, offering three levels of appropriation: *offloading* agency for determining instructional characteristics to the written curriculum, *adapting* written suggestions to meet the unique needs of an individual classroom, and *improvising* or creating new instructional material. He also proposes the construct of *pedagogical design capacity*, a measure of a teacher's ability to manipulate curricular materials for effective use in the classroom, arguing that teachers with high pedagogical design capacity possess a high degree of what Ball et al. (2008) call mathematical knowledge for teaching as well as an ability to identify mathematical knowledge embedded in the curricular materials.

Finally, Sherin and Drake (2008) provide an additional way of interpreting and understanding teachers' use of curriculum materials. Their framework identifies three "interpretive activities" undertaken by teachers when using curriculum materials: *reading*, *evaluating*, and *adapting*. *Reading*, they posit, "involve[s] a focus on the general outline of a lesson or on the details of a lesson" (p. 35). In their framework, as teachers *read*, they *evaluate* specific excerpts, as well as the entire curriculum, in order to make informed decisions about usage. Teachers then *adapt* curriculum by supplementing or replacing certain elements. By mapping these interpretive activities, Sherin and Drake seek to understand the teacher-specific process that transforms curricula into classroom instruction, and ultimately characterize teachers by their "curriculum strategy." They conclude their study stating that "the existence of a teacher's curriculum strategy says nothing about how that teacher's knowledge influences his or her use of a curriculum" (p. 35), which further supports the need for our research.

Theoretical Framework

In this study, we seek to bridge research on teachers' use of curriculum with attempts to further conceptualize the types of knowledge needed for teaching. Doing so, we necessarily adopt many of the assumptions from these two fields. First, we assume that the knowledge, skills, and beliefs of individual teachers play a significant role in the teaching and learning process. Furthermore, as Shulman (1986) stresses, we assume that teaching requires knowledge of pedagogy *and* subject matter knowledge. And finally, we believe that curriculum is necessarily transformed as teachers read, plan, and enact it with their students; therefore, individual teachers will use the same curricular materials in very different ways (Brown, 2009; Remillard, 2005).

Methods: Data Collection and Analysis

Sources of Data

We collected and analyzed data from interviews with seven teacher interviews conducted by our research team members during December 2009, using a semi-structured interview protocol (see Appendix). Information about the teachers' experience is summarized in Table 1. The teachers had varying levels of experience, ranging from 2 years to 32 years. They also varied in regard to how long they had been using the curriculum they were using at the time of the study, with one teacher having used the curriculum only once before.

Specifically, the teachers were asked to talk aloud while simulating the planning of two lessons, one from a familiar curricular package and another using a novel program. Because there is no reason to believe that the ways teachers interacted with familiar materials would be the same as the ways they interacted with novel curricular materials, in this study we looked to include both types of interactions. Following the planning session, the teachers were asked questions designed to access the types of knowledge teachers drew upon when planning.

Table 1.
Teacher Experience

Teacher	Gender	Years Taught	Years Taught with current curriculum	Current Curricula Used	Novel Curricula	Grade Levels Taught
Sam[1]	M	7	5	Investigations	Everyday Math	3rd and 4th
Alex	F	9	7	Investigations	Everyday Math	2nd and 4th
Corey	F	22	1	Scott Foresman	Trailblazers	5th
Jean	F	32	3	Everyday Math	Investigations	1st – 4th
Avery	F	16	6	Investigations	Everyday Math	3rd, 4th, and 5th
Pat	F	12	2	Scott Foresman	Investigations	3rd
Lee	F	2	2	Houghton-Mifflin	Everyday Math	3rd

Methods of Analysis

We began our analysis by using AtlasTi, a qualitative data analysis software package, to code the interviews for the specific tasks teachers engaged in while planning using curriculum materials. We identified and coded for 63 tasks that teachers performed while planning a lesson; we defined a task as a mental process engaged in by teachers, sometimes accompanied by action.

Following this process, we looked for ways to categorize the codes, eventually settling on five categories (*make sense, evaluate, assess fit, predict,* and *plan*). Once these categories were established, we read across the categories to determine the types of knowledge teachers drew upon when performing these tasks and developed displays that allowed us to organize our findings into a conceptual framework for each category. During this stage, we found that two of our categories, assess fit and predict, were not distinct from the other categories. The codes within "assess fit" matched our emergent definition of "evaluate", and each of the tasks within

[1] Pseudonyms are used.

the "predict" category could be described using the definitions of either "evaluate" or "plan". In the next section, we define these categories and describe the types of tasks that compose each of the three categories.

Findings

The three categories of teacher tasks that emerged from analysis of our data, *make sense, evaluate,* and *plan,* align considerably with the a priori categories used by Sherin and Drake (2008): read, evaluate and adapt. This finding supports their assertion of the significant analytical power of these categories; however, the difference in our research questions, resulted in findings that indicated the need to expand Sherin and Drake's "reading" and "adapting" categories for the purposes of this study. First, we use the term "making sense", rather than "reading" because Sherin and Drake focused specifically on what parts of the textbook the teachers read. As will be explained in more detail in the following section, our category includes all of the tasks teachers engaged with to understand what they read and how what they read fit into larger domains. In regard to the "adapting" category, Sherin and Drake's analysis omits any tasks that teachers engaged in as they transformed the written lesson into a plan that were not considered adaptations. Our "planning" category is composed of all of the tasks teachers engage in while actively creating their lesson plan; the tasks Sherin and Drake describe as "adapting" are only one type of "planning" task.

Furthermore, the planning tasks teachers in our study performed align highly with the three levels of artifact appropriation and described by Brown (2008). We will describe how teachers in our study demonstrated off-loading, adapting, and improvising as they interacted with the teachers' guides. The relationship between our emergent framework and those proposed by Sherin and Drake (2008) and Brown (2008) is represented in Table 2. As these tasks are somewhat sequential in nature, we begin by describing what teachers do as they read and *make sense* of the materials.

Table 2.
Relationship between Our Categories and Other Researchers'

Categories of tasks engaged in prior to lesson	**Interpretive Task Categories (Sherin and Drake, 2008)**	**Degree of artifact appropriation (Brown, 2008)**
make sense	reading*	
evaluate	evaluating	
plan	adapting*	offloading, adapting, improvising

*These types of tasks fall within the respective categories in the left column, but do not fully explain the range of tasks we observed.

Making Sense

Making sense involves reading and comprehending the mathematics and pedagogy in the curriculum, then recognizing the way the information presented connects to concepts that are not explicitly discussed. Teachers *made sense* of the curriculum in terms of the *mathematics* and *pedagogy* in many different ways across a variety of domains. Because the goals of our larger project are mathematical in nature, this section contains a full description of the ways teachers made sense of the mathematics in curricular materials, followed by only a brief explanation of the pedagogical considerations they encountered while reading the curriculum.

Understanding the mathematics. Broadly speaking, teachers made sense of the lesson purpose and the individual activities contained within. They also considered how the mathematics presented in the lesson connects to the mathematics that students would learn and had learned over a life time, as well as smaller-scale learning trajectories, such as the mathematics they would learn and had learned during that particular year, unit, or lesson.

When first looking at a specific lesson, some teachers immediately attempted to make sense of the mathematical purpose by reading the "objective", "focus points", or "key concepts" presented in the teacher's guide. For example, Lee began by reading the objective of the lesson: "I would look at the objective and see, you know, what my students are supposed to be learning, and it's, you know, just how to subtract across zeroes". Corey similarly read the objective, then flipped to the assessment to see what the students would ultimately be responsible for doing on their own.

Within the lessons, teachers also made sense of what the text was recommending for individual activities. This entailed reading the instructions until the suggested procedures were clear. The following quotation from Corey demonstrates how he made sense of what the teachers' guide suggests for the classroom:

> [reading from the teachers' guide] "…write the digit that was tossed to the right of the dividend." I know… what the dice were for. [reads] "write … 6 on the board. Have a volunteer show the division steps. … write the digit that was tossed to the right of the dividend." Oh, they're making up their problem. I see. They're making the problem longer. That's not really hands-on. [laughs] They [already] give you a problem. They just ask the kids to roll the dice to add the third digit. Like you write 51 divided by 6, someone rolls the dice and that's the number that we add to the end.

Within the activities, teachers made sense of the individual components. For instance, some activities involve visual representations of mathematical concepts. Other activities include strategies that students could use to solve the problems presented to them. In order to understand the accompanying representations or strategies, the teachers in our study looked to descriptions and examples in the curriculum. Lee made sense of the diagram in a curriculum she had not used before: "It's showing different ways of even, um, you know, keeping track of what they know, what they need, um, knowing which operation to use." While making sense of the activities, teachers sometimes worked individual problems out to better understand what the students were being asked to do.

In general, as teachers made sense of the mathematical content, they also worked to place the mathematical concepts within larger fields of reference by making connections to other representations of the same concept and to other mathematical concepts the students had encountered or would encounter in the future. Teachers made these connections by identifying relationships between representations or concepts. For example, two different representations might be used to demonstrate the same mathematical concept; or, understanding one mathematical concept might be a prerequisite for understanding another. Table 3 provides examples of the various connections the teachers in our study considered when reading a lesson.

Table 3**.**
*Teachers make sense of curricula by making connections***.**

Nature of the connection	**Representative Quotation**
Connecting different representations of the same mathematical concepts.	SAM: "Sometimes more than the base-10 blocks themselves. I guess, honestly, actually doing it sometimes they get very distracted. Often putting something new in their hands is very distracting, but having a picture helps with that. Just putting it vertically and doing it in columns just because they know I am going to see it a lot. We'd often do it this way in class-with breaking it down into 100s, 10s and 1s and then immediately show… show that and kind of put it right next to the old school way."
Connecting to other mathematical concepts learned during the current unit	ALEX: "I guess too I would want to think about like I know with this unit the first.. cause this is the second investigation. The first unit that they do is they.. I think they.. if I remember correctly, like they make these 1000 books. And they do another activity. I forget exactly what changing places is, but I know that they do a lot with practicing place value before they start to actually solve these."

Connecting to other mathematical concepts learned during the current year	JEAN: "There is an 'arranging chair' exercise in Unit 4 of EM, so this is a very similar lesson to a multiplication piece with arrays." JEAN: "I am just thinking about-we are just finishing up the unit that builds on all of this, so we have just done multiplication, division facts, fact families. And we are just doing the arrays today. So it is making the connection- yes, they know this, how can I connect this to what they have already had? We have just introduced factors and products, which is new vocabulary for them. So all of this vocabulary that is on here, they have already had exposure to-so it's really just reminding them."
Mathematics learned over a lifetime	SAM: "It's 27 times 3 or that is part of a problem so they have had to have some addition strategies already. So that is something that we do in third grade and they have been practicing."

Generally, a school year's worth of content is divided into units (sometimes called chapters), and units are composed of lessons. While reading and planning from a text, teachers made connections between representations and between tasks representing the mathematical concept presented in a given lesson. As shown in Table 3, Sam talks about the relationship between doing addition using a written algorithm and adding using base-10 blocks. Similarly, Corey explains the way a symbolic algorithm is reinforced by a more concrete representation of division:

> To segue from the hands-on to the actual algorithm is asking them what does this represent? Once we get the representation in numbers on the board, once we get that numerical representation, just asking and reminding and talking about the "what is this?" "This is a 5." "Is that really 5?" "No, it's 500." You know what I mean? It's a constant, a constant reminder and back-and-forth between the two as we have conversation and as we're doing everything, and we'll go back to the cubes, even in the middle of a lesson or a couple of days later, just to remind it, so it's back and forth.

The teachers in our study also made connections between the lesson they were planning and the lessons and units that surrounded it. In the example in Table 3, Alex consciously considered what the students had done in the lesson previously to identify what skills this lesson built from. Often times, the connections teachers made involved identifying prerequisite knowledge. For instance, Sam, when reading a lesson in *Everyday Mathematics* for the first time, identified the concepts that she felt students should have been exposed to previously:

> So my Math Message follow-up, okay. So Math Message. Take an answer sheet and complete it. So just in looking what they have for the answer for the Math Message, I am assuming that they have done a fair amount of rounding and estimation. Because I think if you hadn't, I think there would be some kids who just tackle it as a 5,980 plus 420.

When considering the previous lessons, the teachers generally drew upon their earlier experience teaching during the current year. As this was not possible when attempting to make connections to future lessons, they instead drew from previous experience teaching at that particular grade level, the curriculum long range planning guides, and the content guides provided to them by state, district or school level administrators.

Teachers in our study also connected the lesson to the mathematics their students had learned and would learn during a given school year. As shown in Table 3, for example, Jean considered the mathematics students had learned in previous units. Corey, on the other hand, identified the position of the division in the lesson she was planning in relation to the types of division students would encounter later in the years, saying, "I think they have to divide 4 digits by 2 digits by the end of fifth grade, so that'll lead to that next, so this is kind of in the middle. The middle-sized problems."

Finally, some teachers took into consideration mathematics that students might have previously encountered and might later encounter during their mathematical careers and lives in general. A number of teachers, for instance, talked about efficiency in operational computation being an end goal, with conceptual understanding as a building block in the process. Lee demonstrated long range thinking in the opposite direction as she considered students' previous experiences. After suggesting that she would use base-10 blocks to help students with regrouping, she justified this decision, remarking that " because they do a lot of that in second grade, most of the students have a good foundation." Similarly, as shown in Table 3, Sam referred to addition strategies learned in a previous grade. When considering this broad learning trajectory, teachers drew upon experience teaching or parenting students at different grade levels, communication with other teachers, long range planning documents created for the school or district, descriptions of connections within the curricula materials themselves, and in the case of considering their students' futures, their own beliefs about what it meant to be a mathematically competent person.

Overall, teachers made sense of the purpose and components of the lesson and made connections between mathematical concepts the students encountered or would encounter during their educational careers. They also paid attention to the representations used to illustrate the mathematical concepts and how those representations could be useful.

Understanding the pedagogy. Teachers also demonstrated various ways of understanding the pedagogical design of the curricula. This type of sense-making was usually explicit only when teachers were asked to simulate planning from a novel curriculum. Broadly speaking, the teachers made sense of the overall structure, noting that a particular curriculum relied on spiraling, for instance. They also identified those components that were present in each lesson of the curricula, like when Alex proposed that the "the math boxes are… like ongoing skill work." Finally, teachers identified the pedagogical theories that the curricula aligned with. For instance, Pat considered the investigative or conceptual nature of two different sections, noting that she usually skips the first and reads the second because the second section is usually more "conceptual":

> Well, history tells me, my precedent is that I find these are not as investigative, they're not conceptual, they're-and I will look at those, but they're not-if I find something here I like, I might not look at those. If I don't, I probably would have looked at these again, because I didn't like this.

In this sequence, Pat skipped reading the first component because of her knowledge of the curriculum, made sense of the second activity, made an evaluation that the second activity was not suitable for her class, then stated that she would go back and make sense of the first activity in order to evaluate its suitability. In many cases, teachers' sense-making and evaluative processes were interwoven. In the next section, we explore more fully the ways teachers evaluated the written curriculum.

Evaluate

Generally speaking, after making sense of the lesson components, teachers *evaluated* the curricular elements and features in several ways and with different goals and audiences in mind. To this end, teachers assessed the difficulty of various aspects of the curriculum, compared and contrasted across curricular programs, identified affordances and weaknesses, and gauged the appropriateness of certain tasks given their teaching context. In the following section, we identify three different audiences teachers evaluate for: *themselves, students in general,* and *their particular students.* In the process of evaluation, teachers drew on a variety of different types of knowledge stemming from their experiences with curricula, teaching, and working with students. Through our analyses, strong evidence points to the idea that teachers' evaluation of curricular materials with regard to students (both students in general and their own particular students) were very closely tied to predicting student responses and behavior. This predictive way of thinking will be discussed in further detail in this section.

In many cases during their planning, the teachers *evaluated for themselves* to determine the usefulness or appropriateness of a given curricular feature or element for themselves as a teacher and in general (see Table 4). They made assessments or judgments about whether or not a particular element was useful for teaching what they believed students should be learning, as well as their own understanding. To do this, they drew on a variety of different types of knowledge: their experiences in the real world and knowing what math knowledge is desirable and necessary, students' needs for standardized tests, their experience reading the curriculum at hand, their experience executing tasks in the past, their experience reading other curricula, and their own learning experiences as a student. In one example, when examining a task, Sam stated, "Like I said with Investigations, I love it. I love they way that they think it through, and its kind of the way I thought about math as a child, and was taught that way." In this particular encounter, Sam evaluated this task based on his personal learning experiences and expectations of curriculum.

Table 4.
Teachers evaluate for themselves

Types of Knowledge Drawn On	**Examples/Quotations**
Desirable math knowledge and level of understanding for the real world	AVERY: "I personally think that having this number sense and understanding what these numbers really mean, it will just make you a better person in math." PAT: "I think it's good for the kids to see that data's used in many different places and many different professions and many different, you know, aspects of their lives."
Students needs in terms of standardized tests	PAT: "So before I teach, for instance, Lesson 4.12, I would come here first and see, you know, see what the GLCEs [Michigan's Grade Level Competence Expectations] are, and I would see that they're going to be using problem solving."
Their experience reading the curriculum at hand	COREY: "The examples are, probably was, was the most powerful for me to understand what this forgiving method was about." JEAN: "This 'Readiness' piece seems much easier to read than what I am currently dealing with.

Their experience executing a task in the past	SAM: "I don't have a problem with it, but I think it gets a little cumbersome."
Their experience reading other curricula	JEAN: [Referring to the teacher's guide] "I would say that these little focus points are easier than what you find… or they are easier to find and pick out because there are fewer of them than in Everyday Math." AVERY: "'Adjusting the Activity'- I didn't expect to see that. I excepted to see something like how to make the problem easier."
Their own learning experiences as a student	SAM: "Like I said with Investigations, I love it. I love the way that they think it through, and its kind of the way I thought about math as a child, and was taught that way."

At other times, teachers *evaluated for students in general* to determine the usefulness or appropriateness of a given curricular feature or element for age-specific, mathematics learners. They *evaluated* in this way to make an assessment about a particular curricular feature or element with regard to student learning. To do this, they drew on a variety of different types of knowledge, including knowledge of other curricula and teaching other curricula, useful curricular features for students, the trajectory of a curriculum, general students at a particular developmental level/age, general student thinking, general student needs, general student performance on standardized tests, and general student struggles (see Table 5). When drawing on these bodies of knowledge, teachers often implicitly made predictions about potential student interactions with curricular features in order to *evaluate* the curricula. In one example, Jean stated, "I do like how they make it really clear that 3 times blank means the number of rows. I think it's important for the kids to know that… 3 'X' is going to tell you 3 groups of blank." Similarly, Alex evaluated to determine if a particular activity was appropriate for 10 year olds, as the curriculum directed. To do this, Alex drew upon knowledge of and experience with students at age 10 and their developmental level to predict the way in which this activity might be taken up and interpreted by students. This prediction allowed Alex to evaluate in a more substantiated way. In the examples in Table 5, teachers' predictions about student responses sometimes predicated their evaluations as they drew on different types of knowledge.

Table 5.
Teachers evaluate for students in general/universal students

Types of Knowledge Drawn On	**Examples/Quotations**
Other curricula and teaching other curricula	PAT: [Assessing the connection between two tasks from separate curricula] "I like the two ideas, mixing the two ideas more, and I think it's more powerful for the kids." *Prediction: students will benefit from mixing the two ideas*
Useful curricular features for students	LEE: "I like that the picture of the actual students' journal page has ample space for them to work."
General students at a particular Developmental level/age	LEE: "Something that I know, through my experience, 3rd graders struggle with, with this concept of subtracting with an internal zero, or you know, borrowing across zeros."
General student thinking	COREY: "I just think it makes more sense for them… keeping the division of the whole number intact instead of trying to just do one at a time."
General student needs	JEAN: "To me it doesn't suit the purpose of getting a student who is really strong in math into a more complex problem."
General student struggles	LEE: "for kids that are really struggling with, you know, with regrouping or the trading method, this would be a lot more streamlined."

Finally, in other instances, teachers *evaluated for their own students* to determine the usefulness or appropriateness of a given curricular feature or element for their particular students at a given time. This form of evaluation was employed because teachers were planning to use curriculum materials with a specific set of students in mind, and they made predictions about how their students would respond based on their experiences with their students. To do this, teachers drew on knowledge of techniques that were successful with their students, pedagogical modes that worked for their students, student performance on assessments, predictions of likely student responses, mathematical ability of their students, students' usual pace, students' needs in terms of standardized tests, students' knowledge of vocabulary, and activities with which students struggled (see Table 6). For example, in examining a particular curricular element, Corey stated, "I find this is way too much for my students to comprehend." In this way, Corey's *evaluation* was based upon experience with her specific students and knowledge of their mathematical ability, embedded in her prediction of their response.

Table 6.
Teachers evaluate for their own students

Types of Knowledge Drawn On	**Examples/Quotations**
Techniques that are successful with the students	SAM: "If I bring them back to the pictorial representation of base 10 things, it clicks for them very easily."
Pedagogical modes that work for the students	SAM: "That seems to work well in my classroom- particularly having the discussion and then going out and doing the discovery piece and then coming back."
Student performance on assessments	SAM: "I have noticed with my class, as we get to the assessments with these too… I am noticing that that is part of the disconnect that they are having in not making that strictly calculating numbers into story problems."
Likely student responses	PAT: "I don't necessarily think they need all this practice, 'cause they're going to look at this and go, "Oh, my gosh! Look at all this *reading*!" PAT: "I think it's great… I think it'll be, I think there'll be an 'Aha' moment, when they get to the actual bar graph part, and they'll go, 'Ah! That's why we did that.'"
Mathematical ability of the students	COREY: "[This is] too difficult for most of my class, without help or guidance, even after all that we do."
Students' usual pace	JEAN: "There are number grids that can be very time consuming for them. Some just take them a lot of time."
Students' knowledge of vocabulary	COREY: "Yes. Absolutely. Yep. [students would understand standard algorithm] And honestly, my reason for saying that is 'cause when we did multiplication and we did the partial products, they don't like to call it partial products. We had a different name for it. But that's, they prefer to clump and use their com-because it makes sense to them. They ha-they cling onto those things that make sense, that are there. Wow! That's the easy way to think about it, you know; it's realistic for them. So, I think they would prefer this to the other. I think they would find this more, I don't know, conducive."
Activities with which students struggle	SAM: "Often putting something new in their hands is very distracting, but having a picture helps with that."

Our analysis suggests that the three ways teachers *evaluate* were not mutually exclusive. In many instances, we observed teachers *evaluating* for different purposes, simultaneously. For example, Corey stated,

I like this method because-it, it breaks down a number as a whole number, instead of

> breaking it down into, you know, when we do the traditional algorithm, it's all just, all you're looking at is, does, how many 8's go into 9? And you, kids will think that, even though I talk about, "Oh, that's not really 9; that's 90." When it comes down to solving it, that's all they're doing.

In this example, Corey *evaluates for herself* first, stating that it is a good method because of the way it presents the information. Following this, she *evaluates for students in general*.

It is also apparent that in order to evaluate, teachers draw on a variety of knowledge and make predictions based on their past experiences. In particular, their knowledge of mathematics influences this evaluation: whether the task addresses what they want to teach, how it is related to previous and later learning of their students, how difficult the task will be for their students, and whether given representations are appropriate for their students. Certainly, teachers' knowledge and predictive capabilities are closely tied to the amount of time spent in the profession. Predictive thinking is where teachers bring in past knowledge of curriculum and knowledge of students to interpret things on the page for the purpose of transforming it into an instructional design. In the following section we will discuss how teachers utilize the processes of making sense and evaluating to plan actual lessons.

Plan

After making sense, evaluating, and possibly predicting how the various curricular offerings would play out in their own classrooms, teachers inevitably transitioned towards planning the lesson. Sometimes they did so after reading through the lesson as a whole; other planning was more integrated as they read through the tasks.

The planning tasks that teachers engaged in fell into three categories. At some point, teachers planned the basic structure of the lesson. This involved *selecting the activities* they would ask their students to engage in. Next, they involved themselves in *transforming the activities as written into a plan for enactment* in their classroom. In some cases, after an evaluation, the activity as written was accepted and transformed into a plan for enactment. In other cases, teachers deemed aspects of the activity inappropriate. During this transformation of these activities, they made modifications or adaptations. Finally, some teachers deemed that the activities presented in the written curriculum were insufficient, so they resorted to creating alternate activities, sometimes using outside resources.

As is the case for teachers' evaluatory tasks, predictive thinking played a significant role in the planning process. Teachers made predictions based on their previous experience with tasks and their knowledge of their own students to plan both how they would set up the activity and specific actions they would engage in during the activity.

Selecting activities. Some teachers read the prescribed activities and planned to do each of them with their students. Others selected amongst the activities that were offered. In the latter case, the act of selecting activities was significantly related to evaluations discussed in the previous section. These teachers considered the time and logistical demands and weighed them against the perceived pedagogical value of the activity. Jean, for instance, used a curriculum package that offered more activities than she felt she could use during a given lesson. In the following quotation involving a game that the curriculum provides in the lesson, she weighs the benefit of the activities against the demands, relying upon past experience with a specific activity or a type of activity.

> The logistics of moving around a baseball field overtakes the math and they end up with very little experience solving multiplication problems. We just don't even do it because it is not worth our time.

We observed another example of this while Corey planned her lesson. Corey usually used the "Investigating the Concept" section of the lesson, but in the case of this particular lesson, she chose not to do this section because she did not perceive it to be laying a conceptual foundation for what is intended to be taught.

Finally, Pat explained her reasoning for choosing to start with a particular task:

> I would probably start out with this kinesthetic investigating the concept right here, a bar graph for birthdays, because I know that would capture their interest. So, and they, since they're a mix of kids, I know they don't know each other birthdays, so it would be pretty good to start out with that.

Generally speaking, after teachers selected and sequenced tasks for use during the lesson, they then transformed the accepted tasks from written to intended. In the following section, we will explain this process as observed through the teachers in our study.

Transforming accepted tasks from written to intended. Teachers engaged in three types of actions when transforming the tasks on the written page into an imagined lesson with their students. The most high level actions involve the structure of the activity, including planning the participation structures, presentation aids, time needed for each activity, and ways of differentiating. Teachers also planned what they would do and say on a more detailed level; this type of planning involved designing their own actions and also anticipating those of their students. These three categories of planning actions are summarized in Table 7.

Table 7.
Teachers plan in three ways

Category	**Tasks**
Structural decisions	plan participation structures, presentation aids, time, and differentiation
Plan their own actions within task	plan what they will do, say
Planning for student responses within task	predict student responses and particular challenges, plan how to respond to these responses, identifying

	assessment opportunities and what they want to hear from students

Structural decisions. As they planned their lessons, teachers interpreted the written words and planned how they would implement the lesson in their own classroom. This involved making structural decisions, like deciding which participation formats to use (whole class, small groups, partners, individuals), which presentation media they would use (white boards, smart boards), how much time should be given to each task, and how they would differentiate their instruction for different learning styles and levels (e.g. working with a small group of students while the others work independently).

Teachers largely drew upon knowledge of their students to make these types of decisions. For example, in considering the use of individual whiteboards, Jean considers her students' competence and focus when using the boards:

> The Mental Math Reflexes I really do try to do each and every time. And we do these on white boards with makers. They all have white boards, an eraser, and a marker. And we do have all of our bins numbered the way that a trainer recommended to us-I am not sure if Everyday Math does it that way. But every student has a number, alphabetically. This group is really good about not doodling on the white boards and just doing the math piece.

Sam considers participation and differentiation in the following quotation, drawing upon his knowledge of difficulties certain students have had in the past and making an implicit prediction that they would have this difficulty with this particular task:

> But, this is probably at the point too where I would pull a handful of kids to work specifically with me in the beginning, call it my guided reading table in the middle of the room. Just to make sure that they are getting a start on it. Because like I said, there are

> some that it is hard to get them started on a strategy. This is where I may even take specifically that small group and actually let someone within the group choose which strategy they want to start with on that problem, but then maybe walk through that whole problem, and walk through one problem with the whole group.

Avery decides to guide students through a task involving maps, rather than letting them work independently. Her prediction regarding her students' confusion is explicit:

> I think it is-with that whole map thing, I think there is going to be quite a bit of confusion. So the "explaining how" would also be guided. A lot of this would be really guided. It wouldn't really be much of them working on their own or independently.

Generally after deciding upon the overall structure of the activity, teachers engaged in smaller-scale planning involving the actions they and their students would take during the individual activities. These actions are detailed in the following section.

Planning their own actions within the task. Teachers also planned for what they would do or say, and what materials they would have ready to reference during the lesson. For example, Lee, who uses a curriculum that assumes a direct instruction approach, thinks about specific steps or ideas that she will highlight as she models solving the problem:

> We just keep building that and saying "Is this number… is this big enough? Or do we need to make it bigger by borrowing?" So we would look at that. But then I would point out to them that because we have zeroes in our problem, that's going to slightly change the order of the steps that we have been working on.

Similarly, Avery thought about individual questions she might ask: "And I might say, 'did somebody use the number line?' or 'did anybody use pictures?' or anything else." Often times, teachers planned their own actions after anticipating student responses during the activity.

Planning for student responses within the activity. Teachers' anticipation of student responses and challenges involved explicit predictions. Alex predicts how his students would respond to a specific problem:

> So I'd probably say some kids are probably gonna do plus two hundred to get 825, and then they're gonna subtract 4 for a next step. So that would be 821. So that would be one way. and then I might write like, you know if a kid did like I guess just jumps of 100 so maybe they started 625 plus 100 to get 725 and then they're next steps would maybe be to add either the rest of the number or the rest of the numbering groups.

Similarly, Pat anticipates challenges, and plans what she will say to try to mitigate these challenges.

> See now I would do that one with them, because they, they have a hard time understanding why do you add these numbers? Why do you subtract these numbers? So I would definitely talk about that, the warm-up and that part 1 with them.

This also involves identification of what they hoped students would say during class discussions and during smaller scale assessment opportunities. For example, Sam anticipated the strategies that he would want to come out of a discussion:

> And just within the context of trying to figure out different strategies, I would just want a list for myself that before this discussion ends, I just want to make sure that we hit these. I have number line, base-10, break it down/break it apart.

All three of these levels of planning involved a high degree of predictive thinking, and these predictions led teachers to a certain orientation towards the written activity.

Degrees of appropriation. Similar to Brown (2008), we found that teachers demonstrated three different orientations to the suggested activities as they planned. Figure 2 shows these orientations and how they fit into our analytical category of plan. Some activities were accepted as written and transformed using the types of actions described above. At other points, teachers decided to make intentional changes to the lesson as it was written. These changes correspond to what Brown calls *adaptations*. Some of these changes were small, like spending more or less time on an activity, or choosing to put off a portion until the next day. Other changes involved modifications of the content of the task. For example, Avery considered changing the introduction activity:

> I am still not sure that I would do that-with just numbers. You know of course you are going to use numbers, but I think I would try and come up with some sort of situation, like "imagine you walked here and did this" or " you had this many and then you got this many more". I think I would do more of the situations than just giving them these numbers and then jumping straight into that.

These adaptations were sometimes made before the transformations described above, and sometimes during.

At times, teachers felt that even with adaptation, the written activities would not be sufficient for their purposes. In these cases, the teachers stated that they would create materials that were not even based off of those in the book. Sometimes this involved creating additional problems, as was the case with Avery when she said she would assign students problems that were from resources other than the *Investigations* curriculum. Other changes were more significant. Corey stated that she would create her own task to start the lesson in a conceptual way. The lesson recommends that given the two digits of a three digit number, students roll a die to determine the ones digit and the resultant number is to be divided by six. She did not view this as conceptual, so, she created her own activity where students would be presented with a real-life situation that they were to solve with the help of small cubes. The creation of these improvised activities involved the same types of decisions described in the section above involving the transformation from written to intended, the difference being that the activity did not originate on the written page.

Overall, when planning, teachers selected the activities they would use, and planned the structure of these activities as well as their actions during the task. The level to which they appropriated the written activity could be described in the manner suggested by Brown (2008); teachers most often off-loaded, and while some made adaptations to the curricula, others improvised by finding other activities elsewhere or creating them on their own.

Discussion

Our findings lead us to two key assertions about the actions that teachers take when planning lessons with curriculum materials. First, teachers rely heavily on their knowledge of their unique context for teaching in order to predict how a task will play out. Second, these categories of planning tasks exhibit a directionally dependent relationship. Teachers' ability to evaluate the material presented to them in the teachers' guide is dependent on their ability to make sense of this material in terms of the mathematics and the connections to other parts of the curriculum. Teachers' abilities to plan their lessons are dependent both upon their evaluations and the ability to make sense of the curriculum.

Teachers rely heavily on their knowledge of their unique classroom context and frequently predict what will happen in that context when planning lessons. Especially when performing actions within the evaluate and plan categories, teachers draw upon experiences they have had with their own students and make predictions about what would happen if they presented the task to their own classroom. This tendency makes intuitive sense, because the design process involves a transformation from the written page, intended for many classrooms, to a plan of action for a specific classroom. We highlight this point here, because it makes evident the importance of predictive thinking—a form of teacher knowledge that is underrepresented in the literature and is vital to understanding the dependent relationship among the types of tasks teachers engaged.

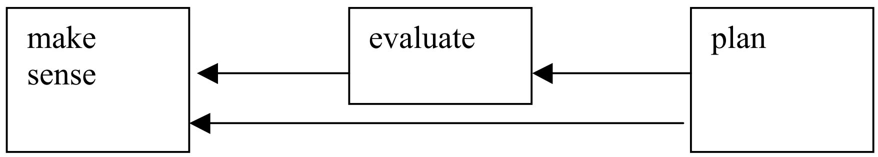

Figure 1. The dependent nature of the three types of tasks teachers engaged in when planning

Figure 1 illustrates the dependent relationships among make sense, evaluate, and plan. It is important to emphasize, however, these actions do not occur sequentially. To the contrary, we found that within the planning process, teachers performed actions from each of these categories in integrated ways. The relationship among them is a dependent one; thus, and the arrows in the figure denote dependence. Teachers' evaluations of curriculum materials rely heavily on how they make sense of what they read in the teachers' guide. These evaluations depend on what teachers understand about the mathematical concepts being emphasized in the lesson and how the tasks and representations demonstrate these concepts. Teachers consider the way the mathematics concepts presented relate to other math concepts found in other portions of the curriculum. They evaluate according to their understanding of the importance of these concepts later on in their students' math education. And finally, evaluations often hinge on how teachers understand the pedagogical approaches taken by the curriculum designers (constructivist, spiraling, etc). The resulting evaluation eventually takes into account these understandings and the teachers' knowledge of their own students as described in our first assertion.

Next, teachers' value judgments highly influence the resulting plans. The degree to which teachers appropriate the written plans depends on this evaluation, as well as other factors, likely including their feeling of agency and ability to make changes. Our data show that teachers plan to shorten, skip or replace activities that they find less valuable.

Finally, after deciding to implement a given task, teachers again rely heavily on how they have made sense of the task or representation. They might explicitly make connections to other math topics or previous lessons. They may choose to highlight certain parts of a task or representation because of its perceived importance. Teachers draw heavily on their knowledge of their students as well during this planning process.

Conclusion

The dependent relationship among the tasks of planning with curriculum materials has implications for how teachers might be supported by the materials they use. If teachers can be supported in making sense of the mathematics in the lesson and the connections to other mathematical ideas and other portions of the curricula, they will likely be better positioned to evaluate and plan their lessons. This support can be provided in a number of different ways. Mathematical content can be explicitly explained and connections to other math concepts can be highlighted. Teachers' guides can point out connections to previous and future lessons. They can also explain complexity of given tasks or problems and provide different approaches to those complex problems. Pedagogical approaches can be explained throughout the text, so that teachers more fully understand how the recommended activities might develop students' mathematical understanding.

If teachers can be supported in making evaluations of the text, this will likely have significant implications to the resulting plans. The primary support that curriculum designers can offer in this domain is explicit rationale for design choices. If teachers understand why certain design decisions were made, they can decide whether they agree or disagree, and plan accordingly. Additionally, designers can include support for teachers as they evaluate for their specific students. For example, a comment like "this activity would provide a review for students who are not fully competent with their multiplication facts" would help a teacher to decide whether the given activity was appropriate for certain students.

Teachers can be supported in the types of decisions that they need to make when transforming the written curriculum to their intended plans. Some textbooks offer possible student responses to tasks. This type of support might especially help teachers who have less experience (and knowledge of their students) to draw from, especially newer teachers. Some teachers' guides offer specific questions for teachers to ask. Some guides even support teachers in making decisions for their specific context. This kind of support is sometimes provided in "if/then" format: if students have a certain characteristic, then they will likely benefit from a certain task. Overall, we argue that textbook designers should take this dependent relationship into consideration when planning the supports they will provide.

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Appendix A

Teacher Interview Procedure

Preparation
Ask the teacher what program s/he is using and about where s/he is in the book. Select a lesson from that book that s/he will be teaching soon and make a copy to bring. Also, we will select a lesson from a different program to bring that focuses on related concepts. (Our goals are to provide the teacher an opportunity to talk across representations, and to get empirical data on subscales of the assessment we are developing. So, make sure that the focus is on what the teacher is thinking about the mathematics in the curriculum they teach. It's not about how s/he teaches.) Be sure to bring additional copies for you, so you can take notes on the pages.

Bring two copies of the consent form.

Review the interview protocol below.

Bring a working audio recorder.

Interview Protocol

Introduction (5 minutes): **I am working with a team of researchers at Western Michigan University and the University of Pennsylvania who are interested in understanding more about how teachers read and use math curriculum materials when planning instruction. We really appreciate your willingness to provide us with your perspective.**

I'd like to audiotape the interview. However, I need you to give me formal permission to do so by signing this consent form. [Review the consent form with the teacher and sign.]

Before we start, do you have any questions for me?

Part I Open (15 minutes):
I'd like to start with the program you are using now. After that I am going to ask you to look at a program you might not be familiar with.

Let's look at a lesson you will be teaching soon. I'd like you to read it as if you were planning to teach the lesson, but as you do, try to think out loud.

As the teacher talks, take notes on your copy of the lesson about things you want to probe later. The teacher might consult other documents, like the core curriculum. Just note which documents and resources are consulted.

When it seems appropriate, ask questions like **"Can you tell me about that decision?"** or **"What is your thinking behind that?"** if you feel you are not getting a sense of what the teacher is thinking. Keep in mind, our goal is to uncover the kind of knowledge the teacher

draws on when thinking through the lesson and how s/he interprets the mathematical ideas within. So ask probing questions, like:
"When you have the students do this problem, number 6, what are you hoping will happen?"
"Why is that important?"
"Can you explain why you decided to skip/change last activity?"
When asking the question, give identifying information—problem 6—that the recorder will pick up.

Part I Questions (10 minutes):
Once the teacher has talked through the lesson, ask these follow up questions (taken from our current subscales). You can skip any question if you feel it was covered in the previous discussion.

1) **What would you say are the most important mathematical ideas in this lesson?**
Probes: **How does this come up in this lesson?** [probe for role of representation and student tasks.]
Why is it important?
(only if it hadn't been answered in your previous conversation) **How did this influence your planning?**

2) **How does this lesson build on what students have learned previously? How is it connected to other lessons?**

3) **How will this knowledge be used later in the year or in future years?**

4) **Are there problems/questions on this page that you think will be easier or harder for your students? Why?**

5) Point to primary model or representation used in the page. Ask, **Is this a model this program uses often? What do you think the authors are trying to accomplish with this model? Does (did) the model work well for your students' understanding? If so, in what ways? If not, why not?**

Part II Open (20 minutes):
Here is a lesson from the xxxxx program. I want you to take a few minutes to look through it and then, like you did before, think out loud about how you might teach the lesson. I understand that this is more difficult to do because you are unfamiliar with the program.

As the teacher talks, take notes on your copy of the lesson about things you want to probe later. The teacher might consult other documents, like the core curriculum. Just note which documents and resources are consulted.

When it seems appropriate, ask questions like **"Can you tell me about that decision?"** or **"What is your thinking behind that?"** if you feel you are not getting a sense of what the

teacher is thinking. Keep in mind, our goal is to uncover the kind of knowledge the teacher draws on when thinking through the lesson and how s/he interprets the mathematical ideas within. So ask probing questions, like:
"When you have the students do this problem, number 6, what are you hoping will happen?"
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Once the teacher has talked through the lesson, ask these follow up questions (taken from our current subscales). You can skip any question if you feel it was covered in the previous discussion.

1) **What would you say are the most important mathematical ideas in this lesson?**
   Probes: **How does this come up in this lesson?** [probe for role of representation and student tasks.]
      Why is it important?
      (only if it hadn't been answered in your previous conversation) **How did this influence your planning?**

2) **What kinds of prior knowledge would you expect this lesson to be building on?**

3) **How do you think/hope this knowledge will be used later in the year or in future years?**

4) **Are there problems/questions on this page that you think will be easier or harder for your students? Why?**

5) **Point to primary model or representation used in the page. What do you think about this model? What do you think the authors are trying to accomplish?**

6) **Do you see any connections or similarities between the two lessons you looked at today?**

Thank you so much for your time.