

**WHAT'S THE STORY WITH STORY PROBLEMS? EXPLORING THE
RELATIONSHIP BETWEEN CONTEXTUAL MATHEMATICS TASKS, STUDENT
ENGAGEMENT, AND MOTIVATION TO LEARN MATHEMATICS IN MIDDLE
SCHOOL**

By

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ABSTRACT

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Contextual tasks, or tasks that include scenarios described at least in part with nonmathematical language or pictures, are a long-standing part of mathematics education in the United States. These tasks may have potential to promote student engagement and motivation to learn mathematics by highlighting applications of mathematics to everyday matters and generating interest in the content (e.g., van den Heuvel-Panhuizen, 2005). Yet, several scholars have challenged the belief that contextual tasks can serve to motivate students and problematized their role in mathematics curricula (e.g., Chazan, 2000; Gerofsky, 2004). Some theoretical and empirical evidence exists to support both claims.

This study addresses a call for more research on how student motivation and engagement in mathematics are influenced in specific learning situations, namely, working on contextual tasks. *Motivation* describes a person's choice, persistence, and performance when engaging in an activity (Brophy, 2004), whereas *engagement* is active involvement in a learning activity (Helme & Clarke, 2001) and the observable manifestation of motivation (Skinner, Kindermann, & Furrer, 2008). The purpose of this multiple-case study was to consider the general questions, *Do contextual tasks have potential to engage students, and if so, under what circumstances?*, and *How do students experience these tasks relative to their motivation to learn mathematics?* In particular, I considered enactment of tasks across lessons in two 7th-grade mathematics classrooms. Through analyzing data from observations, lesson-specific teacher and student

surveys, and focus group interviews, I identified the most and least engaging lessons for students, then characterized the tasks in these lessons as written and enacted.

I found that students were more likely to show high levels of engagement in contextual tasks than noncontextual tasks. Their engagement in contextual tasks was related, however, to the learning goals of the task, its placement in a unit, and the function of the context in problem solving. In high-engagement lessons, the tasks tended toward open-ended tasks with contexts central in solving the problem. I also found differences in the way students and teachers attended to contextual features of tasks between the high- and low-engagement lessons. Students drew on the context more in the high engagement lessons, and were more likely to connect the context to the main mathematical ideas in the lesson. Teachers also paid more attention to contexts and in more diverse ways across the high-engagement lessons.

I also drew on the data sources using expectancy-value theory to explore in depth how students responded to individual tasks relative to their motivation to learn mathematics. Aspects of tasks students attended to (including contexts) when reflecting on the value of mathematical content and their experiences in lessons was related to their underlying motivation to learn. Trends across groups of students, however, indicate that task contexts play little role in promoting students' valuing of mathematics or beliefs that they can be successful on a task.

Based on these findings, I argue that some contextual tasks engage students by eliciting genuine interest in the context itself, providing entry into and support in solving the problem, and anchoring the instruction to provide students a shared experience on which to develop their understanding of the mathematical concepts. Yet, contextual tasks do not necessarily have the same potential to motivate students to learn. I discuss implications for teachers, curriculum design, and future research regarding the purpose and function of contextual tasks.

To Kevin, Penelope, Adrianna, Donald, and Edmund

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KEY TO ABBREVIATIONS

CCSSI	Common Core State Standards Initiative
CMP	Connected Mathematics Project (Lappan et al., 2006, 2014)
NCTM	National Council of Teachers of Mathematics

CHAPTER 1

INTRODUCTION

Negative mathematics dispositions, in the form of math anxiety, avoiding challenge and higher level mathematics, or believing one is not really a “math person”, are a widespread plague in the United States. These beliefs influence students’ motivation to learn mathematics (or not), and are influenced by classroom instruction (e.g., Brophy, 2004). Motivation to *avoid* mathematics warrants a close consideration of mathematics instruction and curricula that can promote student engagement and motivation to learn (Turner & Meyer, 2009). These issues are in fact receiving attention; for example, the National Council of Teachers of Mathematics (NCTM) recently published two books for teachers to address mathematics-related motivation, engagement, and dispositions (Brahier & Speer, 2011; Middleton & Jansen, 2011).

Middleton and Jansen (2011) discussed several themes in literature on students’ motivation to learn mathematics. One is that although motivation to learn develops early and stays relatively stable over time, student motivation can be influenced by instructional practices and tasks. That is, a student’s level of motivation might be resistant to change, but is not innate, and can be molded through localized experiences with mathematics in and out of the classroom. This points to the importance of considering the potential for specific mathematics lessons or tasks to engage and motivate students.

Adding contexts to mathematics problems is believed to have the potential to promote student motivation, among other purposes (e.g., Chapman, 2006; Meyer, Dekker, & Querelle, 2001; Middleton & Jansen, 2011; Mitchell & Carbone, 2011; van den Heuvel-Panhuizen, 2005). On one hand, several curricula and instructional research programs have been designed around contextual tasks, either to meet recommendations by NCTM to put more emphasis on real-world

applications or to attempt an explicit connection between students' everyday, cultural mathematical activity and school mathematics. Their developers argue that these tasks can serve to catch students' interest and engage them in the mathematics along with supporting their learning (e.g., Civil, 2002; Gutstein, 2003; Lappan & Phillips, 2009; Romberg & Shafer, 2003; Silva, Moses, Rivers, & Johnson, 1990). On the other hand, several scholars have argued that believing contextual tasks will motivate students is too simplistic. They have problematized the use of contextual problems and called for a reconsideration of their role in the curriculum (Boaler, 1993; Chazan, 2000; Gerofsky, 2004; Sullivan, Zevenbergen, & Mousley, 2003; Verschaffel, Greer, & De Corte, 2000). Meanwhile, it seems the popular opinion of contextual tasks is negative, as "the hated word problems" (Thomas in Thomas & Gerofsky, 1997, p. 21).

This debate suggests some complexity in the relationship between contextual tasks and student motivation to learn mathematics. There is reasonable theoretical support for both views, but there is a need for more empirical evidence to confirm or dispute the motivational potential of various types of contextual tasks under various circumstances. Consequently, the purpose of this multiple-case study was to gain a more nuanced understanding of the relationship between the use of contextual tasks, engagement, and student motivation to learn in secondary mathematics classrooms.

A Study of Engagement, Motivation, and Contextual Tasks

Conceptualization of Key Terms

I use the term *contextual task* or *contextual problem* to refer to any task or project that includes some kind of realistic or imaginary scenario described at least in part by nonmathematical language or a nonmathematical pictorial representation (Li, 2000). The term is both inclusive and exclusive. It is inclusive because it covers the variety of other terms used in

the literature such as word problems, story problems, real-world or applied problems, and real-world connections. It is exclusive in the sense that it is limited to a particular subset of tasks enacted in mathematics classrooms. “Context” can also refer to the physical classroom environment; the social, cultural, or historical setting; or the placement of a task within in the curriculum (i.e., where in the unit and course a topic is taught). With the definition used here, contextualization is a feature of a task as written or designed.

Motivation is an umbrella construct used to describe a person’s choice, persistence, and performance when engaging in an activity, particularly a goal-directed activity (Brophy, 2004). It is related but not equivalent to constructs like values, beliefs, and attitudes. Motivation encompasses the reasons underlying people’s behavior (Middleton & Jansen, 2011). To consider the effects of contextual tasks on motivation, I focused on student *motivation to learn*, meaning a “tendenc[y] to find academic activities meaningful and worthwhile and to try to get the intended learning benefits from them” (Brophy, 2004, p. 16). This definition focuses on learning over performance-based rewards like grades, making it different than extrinsic motivation. It is also a different construct than intrinsic motivation, which relates to enjoyment of an activity. Motivation to learn is in essence different than the motivation to do other things (e.g., sports, games, playing music) because of the nature of school and its constraints (Brophy, 2004). Motivation to learn, however, can coexist with and be supported by extrinsic and intrinsic motivation.

The term engagement is sometimes used synonymously with motivation, but they are not equivalent (Fredericks & McColskey, 2012; Middleton & Spanias, 1999). Basically, what students actually do in the classroom may not accurately reflect their level of motivation to learn. For example, a student might value learning mathematics and believe they can be successful (i.e.,

they are motivated to learn), but still sleep in class (i.e., be disengaged) because they stayed up too late the night before. Or, students might express low motivation to learn, but engage richly in academic tasks that are interesting to them. Motivation is the generally non-observable mechanism underlying people's behavior, whereas *engagement* is the observable manifestation of motivation (Skinner, Kindermann, & Furrer, 2008) as active involvement in a learning activity (Helme & Clarke, 2001). All students are motivated to do something, and that drives their level of engagement—which is more prone to change with specific classroom situations. The relationship between engagement and motivation is complicated, though, as various definitions of engagement are inextricably related to other motivation constructs.

Most literature on engagement identifies interrelated components of school engagement—including behavioral, emotional, and cognitive engagement—making it a multidimensional concept (Fredericks, Blumenfeld, & Paris, 2004). In their review of literature on academic engagement, Fredericks et al. (2004) describe *behavioral engagement* as relating to participation in the classroom, adherence to rules, and absence of disruptive behaviors; that is, being on task. *Emotional engagement* refers to student affect related to school activities, including happiness, sadness, boredom, and excitement. *Cognitive engagement*, which is closely linked to motivation to learn, refers more to the quality of behavioral engagement, or the level of investment students make in learning content. It incorporates challenge seeking, hard work, and self-regulation (Fredericks et al., 2004).

In this study, I focused on emotional and cognitive engagement and the interplay between them. Behavioral engagement has primarily been captured at the school level (e.g., participation in extracurricular activities, attendance). It is also difficult to conceptually and practically separate behavioral engagement and the other types of engagement. Moreover, as will be

discussed, motivation theory suggests emotions (e.g., enjoyment, surprise) are an inherent part of motivation. Thus, I plan to include emotional engagement in this study because although motivation to learn is linked most closely with cognitive engagement, it seems emotional engagement cannot be separated from student motivation to learn (Stipek et al., 1998). From this point on, including in my research questions, when I use the term engagement I refer to both cognitive and emotional engagement.

Along with engagement, I also aimed to explore broader motivational factors underlying student behavior, such as the value students place on mathematical content. Accordingly, I refer to both engagement and motivation throughout the following chapters, recognizing they are different but related constructs. In the literature review, I explicate on research linking motivation and engagement.

Purpose Statement

The purpose of this study was to gain a more nuanced understanding of the relationship between the use of contextual tasks in mathematics classrooms and student engagement and motivation to learn mathematics, which can inform curriculum development and instructional decisions. More specifically, I aimed to identify lessons in which students exhibited high or low levels of engagement, characterize the tasks in those lessons, and explore the motivational foundations for student engagement in contextual tasks. The cases were classes of 7th-grade students in which a variety of contextual tasks were a regular part of instruction. That is, students worked on contextual tasks on their own, in small groups, or as a class multiple times per week.

Situating the Study in Extant Literature

Student motivation to learn mathematics is an important outcome to study. First, student motivation and engagement has been empirically linked to student achievement in mathematics

(see, e.g., Cordova & Lepper, 1996; Singh, Granville, & Dika, 2002; Stipek et al., 1998), which is the ultimate goal of school mathematics. Though the relationship between motivation and engagement and student achievement is complex and, in some cases, nonlinear, many studies link the quality of student engagement with positive gains in learning (Fredericks, Blumenfeld, & Paris, 2004).

Second, some argue that students' positive mathematical dispositions should be viewed as a core intended outcome of mathematics education (National Research Council, 2001; Brophy, 2008). That is, teachers and researchers should attend to "changes and acquisitions in the motivational aspects of learning (i.e., certain content-related values, dispositions, and appreciations), not just the knowledge and skill aspects (Brophy, 2008, p. 135). In part, this focus serves to address and counteract widespread negative attitudes toward mathematics. Middleton and Jansen (2011) describe this as a "motivational epidemic—motivation to avoid mathematics" (p. 184). This response does not seem to generalize to other school subjects, encouraging the study of mathematics and motivation in particular. "The longevity of math anxiety, both in popular lore and research, indicate that the linkage of motivation and mathematics is a compelling argument for considering how mathematics teaching, learning, and motivation are negotiated in the classroom" (Turner & Meyer, 2009, p. 527).

Another reason for focusing on engagement and motivation to learn mathematics is that meeting the calls for mathematics education reform such as those by NCTM (1989, 2000) and the Standards for Mathematical Practice in the Common Core State Standards for Mathematics (CCSSI, 2010) require students to be actively involved in the learning process. Unlike in lecture-based classrooms, teachers are dependent on students' intellectual engagement in student-centered classrooms based on inquiry, discussion, and reasoning, (Chazan, 2000). Thus, it is

worthwhile to consider curricular features and instructional practices that may influence student engagement and motivation.

Taken together, literature suggests that interest and engagement are malleable. Tasks and classroom instruction matter, which is where contextual tasks come in—they can serve to promote or hinder student engagement and motivation to learn. An important feature of contextual tasks is their ubiquitous nature—word problems have a presence in nearly all mathematics curricula and are a familiar part of school mathematics (Gerofsky, 1996). This feature makes them a potentially strong place to start in increasing student motivation and engagement. They are also uniquely positioned to support engagement among students typically underrepresented in mathematics, including students of color. Contexts that are personally relevant can be developed to more actively and deliberately link content to students' racial, ethnic, and cultural experiences (Tate, 1996).

The claim that contextual tasks have the potential to promote student motivation seems to run counter to the prevailing theme in school culture that students dread story problems. This theme is implied in Thomas's (1997) statement, "lots of people don't call them 'story problems.' I refer to them usually as 'the hated word problems'" (p. 21). Similarly, in her description of the typical mathematics classroom, Wilson (2003) wrote, "Ample time is usually left for practicing problems, and an audible sigh of relief is heard whenever word problems are not assigned" (p. 4). This suggests a need to take a closer look at the relationship between student motivation and contextual tasks. Whereas the relationship between contextual tasks and problem solving strategies, and between contextual tasks and student learning, has been the focus of recent research (e.g., Walkington, Sherman, & Petrosino, 2012; Walkington, in press), the relationship between contextual tasks and motivation has been inadequately investigated empirically.

Final Note on the Importance of the Study

As I finished the data analysis and wrote my final chapters, I had the opportunity to return to the classroom to teach middle school mathematics. I am reminded daily of how salient engagement is in a student-centered, problem-based classroom—little is learned or accomplished without it. If contextual tasks have potential to support student engagement and motivation, it is worth investigating. The immediacy of motivating students to learn mathematics typically falls on teachers. Though it is apparent that no widely-used written mathematics curriculum can incorporate contextual tasks that will be motivating for all students (e.g., Boaler, 1993), it is also unlikely that teachers will be able to develop their own contexts that will be highly relevant for all their students, due to the demands on teachers' time and knowledge and the diversity existing in a single classroom (Chazan, 2000). A clearer understanding of the types of contexts and instructional practices that relate to student engagement and motivation could be valuable for teachers as they select and enact tasks, and for curriculum designers as they design these tasks and support teachers in using them.

Overview of Forthcoming Chapters

In the next chapter, I review literature on contextual tasks, motivation in mathematics education, and theoretical and empirical links between contextual tasks and motivation. I close the chapter with the research questions and a description of expectancy-value theory and how it provided a theoretical framework for the study. Chapter 3 begins with the research strategy I employed, then describes the participants in the two classrooms. I then outline how data was obtained and analyzed from classroom observations, student and teacher surveys, and focus group interviews to capture student engagement and motivation and to characterize contextual tasks.

In Chapter 4, I describe the most and least engaging lessons and patterns in the characteristics of the tasks (as written and as presented to students) in these lessons. Descriptive statistics support the identification of noteworthy lessons and begin to explain the relationship between the use of contextual mathematics tasks and student engagement in those lessons. In Chapter 5, I focus on how teachers and students enacted the tasks, particularly the contextual aspects of tasks, in the high- and low-engagement lessons. Chapter 6 describes in more detail the relationships between task contexts and student motivation to learn. Drawing primarily on survey and interview data, I consider how students responded to particular tasks and contexts, how their engagement reflected (or not) their expressed motivation to learn mathematics, and how their work with contextual tasks seemed to influence their motivational beliefs. I present cases of students who expressed diverse views of mathematics and themselves as doers of mathematics and discuss how they described their experiences in certain lessons. In Chapter 7, I conclude with reflections on the posited answers to the research questions, suggestions for future studies building on the results of this investigation, implications for researchers, and implications for teaching and curriculum development that support student cognitive and emotional engagement with contextual tasks.

CHAPTER 2

LITERATURE REVIEW

With this study, I aimed to explore two main variables: contextual tasks, including their implementation in classrooms, and student motivation to learn mathematics. In this section, I start with an overview of the purposes contextual tasks serve, historically and presently. Next, I discuss literature related to the implementation of contextual tasks. Then, I briefly synthesize literature on motivation to learn mathematics (and clarify the relationship between motivation and engagement). Finally, I consider theoretical and empirical links between contextual tasks and motivation in order to highlight the need for the study.

Contextual Tasks in the Mathematics Curriculum

Purposes of Contextual Tasks, Through History and Present

Contextual tasks are a long-standing part of mathematics education, though their role in the curriculum has changed over time. Gerofsky (1996) wrote, “the form and addressivity of school mathematics word problems is recognizable nearly universally among most people who have attended school mathematics classes” (p. 37). She argued that contextual tasks persist perhaps in part simply because of tradition—teachers and parents did those problems, so they teach them, and so on. But others claim contextual tasks have served multiple important purposes in school mathematics, which I explicate in this section.

Texts including contextual tasks date back to at least 1850 B.C. across broadly diverse cultures (Gerofsky, 1996; Verschaffel et al., 2000). For example, the Rhind papyrus is an Egyptian mathematics “textbook” of sorts that dates written in approximately 1550 B.C. (Trustees of the British Museum, n. d.). It contains 84 mathematics problems and tables of values, including both non-contextual and contextual arithmetic problems. The contextual tasks

seem to represent practical problems faced by scribes, such as division of food for men and livestock.

Historically, contextual tasks have served multiple purposes, to some extent reflecting beliefs about mathematics and mathematics education at the time (Verschaffel et al., 2000). Like in the Rhind papyrus, one purpose was to provide “training exercises in practical skills aimed as [sic] specific classes of students” (p. 140) such as surveying, sales, and navigation. Tasks of this nature were evident in mathematics texts as early as the 13th century, alongside non-contextual tasks introducing central mathematics facts (e.g., Fibonacci’s *Liber Abaci*). Another historical purpose for contextual tasks was to serve as puzzles or exercises in “recreational mathematics.” These ancestors of traditional story problems tend to ignore realistic constraints, highlighting instead some aspect of mathematical structure.

Since the early days of mathematics education in the United States, textbooks have included a mix of contextual and non-contextual tasks, reflecting the fact that mathematics in school served dual purposes: the “cultivation of reasoning power” and as an “instrument for solving everyday problems (Kliebard & Franklin, 2003, p. 401). The relative balance between the types of tasks has shifted over time, with larger societal changes that influenced the demographics of the student population and the perceived role of mathematics in school, like industrialization, immigration, and World War II (Kilpatrick & Izsák, 2008, Kliebard & Franklin, 2003). During the New Math Era in the 1950s to the 1970s, there was a major shift in school mathematics curricula toward logic, deductive reasoning, proof, and emphasis on structure and sets (Fey & Graeber, 2003)—deemphasizing the role of any contextual tasks. When New Math fell out of favor, the back-to-basics movement brought new emphasis on rote procedures, again downplaying practical application problems but focusing instead on what we

now consider “classic” story problems—mixtures, distance-rate-time, coins, and so on (Coxford, 2003). These problems can usually be solved using rote procedures, as “routine applications without judgment or any higher-level thinking skills” (Verschaffel et al., 2000, p. xiii).

Finally, a reform movement driven by the National Science Foundation (NSF) and NCTM’s publication of standards documents placed renewed emphasis on real-life applied tasks with more complex problem-solving scenarios over the last two decades. Two core documents—the NCTM Curriculum and Evaluation Standards for School Mathematics (1989) and Principles and Standards for School Mathematics (2000) called for increased use of tasks and practices that highlight mathematics in real-life situations and the applications of mathematics to these scenarios. NCTM cites both learning and motivational purposes for contextual tasks (NCTM, 2009). Connections between mathematics and real-world problems made through modeling, for example, offer several benefits: connecting mathematical ideas and tools, providing opportunities for mathematical reasoning, providing access to mathematical ideas for diverse learners, and highlighting the practical need for specific mathematical ideas and offering opportunities to apply them (NCTM, 2009). Most recently, the Common Core State Standards include mathematical modeling as a standard of mathematical practice, primarily to provide opportunities for students to apply mathematics to solve everyday, societal, and workplace problems (CCSSI, 2010).

Accordingly, curriculum developers have emphasized the role of context in supporting students’ learning by connecting everyday and school mathematical activity. For instance, contextual tasks can support the transfer of mathematical knowledge to out-of-school settings (Meyer et al., 2001; Putnam, Lampert, & Peterson, 1990). Also, problems drawing on familiar contexts can give students entry into complex tasks by connecting to informal knowledge

(Carraher, Carraher, & Schliemann, 1985; Walkington, Sherman, & Petrosino, 2012). A secondary purpose contextual tasks are hypothesized to serve is to foster student engagement and interest—or, to promote student motivation to learn mathematics (Chapman, 2006; Meyer et al., 2001; van den Heuvel-Panhuizen, 2005; Verschaffel et al., 2000).

Writers and developers of curricula and programs based on contextual tasks often draw on both of these purposes in justifying the emphasis on these tasks (e.g., Civil, 2002; Gutstein, 2003; Lappan & Phillips, 2009; Romberg & Shafer, 2003; Silva et al., 1990). These curricula and programs have a variety of forms. One form is comprehensive NSF-funded, nationally published curricula based on the NCTM *Standards* documents (1989, 2000); namely, the Connected Mathematics Project (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006; Lappan, Phillips, Fey, Friel, Grant, & Stewart, 2014) and Mathematics in Context (National Center for Research in Mathematical Sciences Educational Staff, 1998; Romberg & Shafer, 2003). Another form is teacher-produced tasks that connect students' mathematical thinking with community-based contexts, drawing on students' multiple funds of knowledge (Aguirre et al., 2012; Civil, 2002, 2006, 2007) and/or social justice issues (e.g., Gutstein, 2003, 2007a, 2007b). Students themselves can also generate contextual problems, based on tasks provided by teachers or on their own interests (English, 1997). As an example, I will describe one Standards-based middle school curriculum and identify the reasons provided by the curriculum developers for this emphasis.

Connected Mathematics Project—An Example

The Connected Mathematics Project (CMP, Lappan et al., 2006, 2014) originated as an NSF-funded comprehensive curriculum (grades six to eight) designed to meet recommendations for teaching and learning school mathematics by NCTM in the Standards documents (1989,

2000). CMP has several key features: it is problem-centered; it is organized around big mathematical ideas to be connected and coherent; it builds conceptual and procedural knowledge; it is based on research on learning, mathematical concepts, motivation, and policy; and it provides support for teachers along with students in order to meet increased content and pedagogical knowledge demands (Lappan, Phillips, & Fey, 2007; Lappan & Phillips, 2009).

According to the authors, the primary reason for designing a mathematics curriculum based largely on contextual problems is to promote student learning. Students are encouraged to engage in authentic mathematical activity by “exploring interesting mathematics situations, reflecting on solution methods, examining why the methods work, comparing methods, and relating methods to those used in previous situations” (Lappan et al., 2007, p. 73). Problem contexts also support students in remembering and retrieving the embedded mathematics in new situations. Individual problems should meet the overall goals of the curriculum—to promote conceptual and procedural understanding, allow teachers to assess what students know on a regular basis, encourage student collaboration, and allow multiple strategies and conjectures.

Furthermore, the authors present contextual tasks as having the potential to be interesting to students and provide familiarity that will give them access to the mathematics (Lappan & Phillips, 1998). Problem settings should be engaging, and alternative settings should be chosen by the teachers to increase engagement when appropriate. Original letters written by the CMP authors (printed in Lappan & Phillips, 2009) indicated that contextual problem scenarios should: a) promote mathematical thinking, b) generate interest and motivate the study of mathematics, and c) support collaborative learning and multiple approaches to solve problems. Here, we see the dual-emphases on contextual tasks to promote student learning and student motivation, reflecting the purposes the tasks have served over time. Lappan and Phillips do not, however,

emphasize the role of contextual tasks in helping students transfer or apply mathematical knowledge to solving everyday tasks.

So far, I have considered the nature and purpose of contextual tasks in mathematics education. There are significant bodies of literature on the role of these tasks in the curriculum and student thinking on these types of tasks. For the purposes of this study, however, I want to consider what we know about how contextual tasks are actually implemented in the classroom, so I turn next to this topic.

Implementation of Contextual Tasks in Mathematics Classrooms

Few studies exist that specifically address how teachers implement the context of a mathematics task (c.f. Chapman, 2006; Wernet, 2011). Extant research has shown, however, that the way tasks are enacted in classrooms can and often does differ from the task as written. The mathematics task framework, for example, conceptualizes tasks as existing in three phases: as written in curricular materials, as set up by the teacher, and as enacted in the classroom (Henningesen & Stein, 1997). The *enacted curriculum* is defined as an interaction in the classroom around curricular materials and necessarily involves teachers and students (Remillard, 2005). Set-up and enactment are influenced by the teacher's knowledge and beliefs, classroom norms, the nature of the task, and dispositions toward teaching and learning. The framework was used specifically to investigate changes in the important characteristics of the task and the cognitive demand, or "the kind of thinking processes entailed in solving the task" (Henningesen & Stein, 1997, p. 529).

Similarly, I studied contextual tasks as written and as enacted in 8th-grade classrooms and found that teachers and students used particular moves that explicitly addressed the context (Wernet, 2011). These moves grouped into five categories: positioning, clarifying, elaborating,

referencing, and making meta-level comments on the context. To varying extents, using these practices changed the centrality and authenticity of the tasks as written. For example, *positioning* occurred when students and teachers put themselves and others into the problem situation through telling personal stories, using personal pronouns, and exhibiting an emotional response to the context. Positioning served in some cases to raise the authenticity of tasks by making the problem scenario seem more likely to occur. *Elaborating* on the context, including inventing more personal contexts, also raised the *authenticity*. *Referencing, clarifying, and making meta-level remarks* about the context made the context more central in problems. These findings (summarized in Figure 1) support other findings that teachers take particular approaches in dealing with problem contexts, which either draw attention to or from the context and control the extent to which students drew on personal knowledge and experiences (Chapman, 2006).

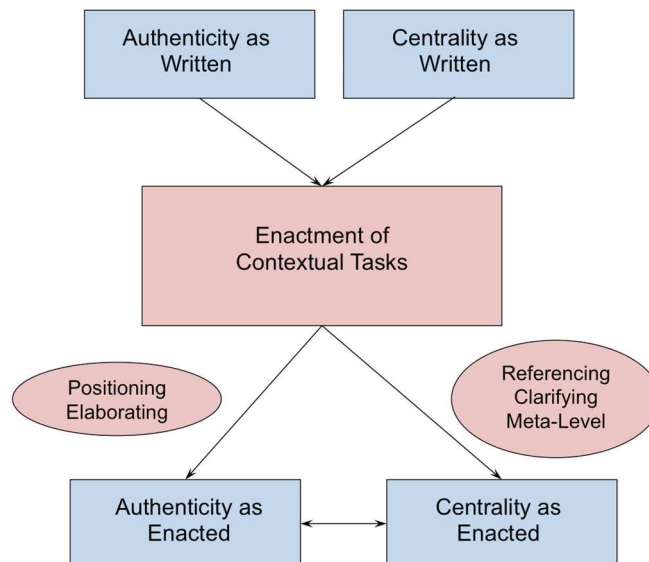


Figure 1. Diagram showing how certain actions by the teacher and students during task enactment changed the authenticity and centrality of the contexts as written in the curriculum (Wernet, 2001).

There is some indication that how contextual tasks are implemented may influence students' responses to the contexts (Nisbet, Langrall, & Mooney, 2007; Wernet, 2001). Nisbet et

al. (2007) found that when middle school students worked on statistics tasks involving contexts in which one member of a small group was highly interested (e.g., tennis and music), groups drew more heavily on the context in solving and showed greater levels of engagement. I found that certain practices (e.g., inventing new contexts) and types of context (e.g., those related to community issues) generated the most class discussion with extensive student contributions (Wernet, 2011). These findings, however, were peripheral to the research questions and are suggestive about the relationship between contextual tasks and engagement, not conclusive. In the next section, I describe literature on student engagement and motivation, including the relationship between these constructs, before turning to empirical research more explicitly linking contextual tasks with engagement and motivation.

Student Motivation to Learn Mathematics and Engage in Mathematics Tasks

Motivation to Learn Mathematics

A large body of literature exists on student motivation in general (see Wentzel & Wigfield, 2009 for a comprehensive review). Motivation is sensitive to context and content (Middleton & Spanias, 1999; Turner & Meyer, 2009), so I focus here on literature about motivation and mathematics. Relatively few studies have explicitly drawn on motivation and mathematics education constructs (Turner & Meyer, 2009), but a few consistent themes appear throughout the extant literature across major motivation theories (Middleton & Spanias, 1999). The following themes and issues are drawn primarily from reviews of literature on motivation to learn mathematics (Middleton & Spanias, 1999; Turner & Meyer, 2009) and the practitioner-oriented book *Motivation Matters and Interest Counts: Fostering Engagement in Mathematics* (Middleton & Jansen, 2009) in which the authors use extant literature and extensive personal experience in mathematics classrooms to propose essential principles related to motivation to

learn mathematics. I highlight these themes to frame the “factors of motivation” referenced in my research questions. Fewer studies have addressed engagement in mathematics classrooms and the relationship between motivation and engagement (Jansen, 2008), and as previously stated, motivation and engagement are often used interchangeably in the literature. So although the following themes emphasize motivation, engagement is implicitly addressed as well.

Motivation to learn is both learned and adaptive. Generally, motivation develops early in students’ school mathematics experiences, appearing to be relatively stable over time but also influenced by instruction (Middleton & Spanias, 1999; Middleton & Jansen, 2011). Middleton and Jansen (2011) argued that motivation to learn mathematics is both learned and adaptive. That is, levels of motivation are neither innate to an individual nor inherent to mathematics. Students self-regulate their behavior in the classroom relative to their beliefs and previous experiences related to mathematics, teaching, and learning.

Learning goals are preferable to performance goals. A second theme is the importance of intrinsic motivation over extrinsic, and learning (i.e., mastery) goals over performance goals (Middleton & Spanias, 1999; Middleton & Jansen, 2011). A student with performance goal orientation shows concern with appearing smart, and success is about outperforming others or receiving good grades with little effort (Ames & Archer, 1988). A learning goal orientation stresses the process of learning and gaining skills and knowledge, and success is based on effort and not ingrained ability (Ames & Archer, 1988). Students need some expectation they can be successful in order to be motivated in the mathematics classroom (Middleton & Jansen, 2011; Middleton & Spanias, 1999; Wigfield & Eccles, 2000). The link between learning and motivation, however, is mediated by the social nature of mathematics—students want to experience relatedness in the classroom and *appear* competent in addition to

feeling competent (Middleton & Jansen, 2011). It is further mediated by the interpretation of previous mathematics-related experiences by students, parents, and teachers (Turner & Meyer, 2009).

A growth mindset is preferable to a fixed mindset. Similar to goal orientation, a student's mindset toward intelligence influences their engagement and perseverance, and thus their motivation to learn mathematics. Someone with a *growth mindset* toward mathematics believes that ability to learn or be good at mathematics can be developed through effort, while someone with a *fixed mindset* believes these qualities are an intrinsic part of a person (Dweck, 2006; Suh, Graham, Ferrarone, Kopeinig, & Bertholet, 2011). Students with a growth mindset persist when faced with difficult tasks, accept and learn from constructive criticism, and are inspired by others' success. Conversely, students with a fixed mindset avoid challenge, give up easily, disregard constructive criticism, and feel threatened by others' success (Suh et al., 2011). Mindsets toward learning shape students' level of achievement and are related to gender and racial achievement discrepancies and motivation to pursue careers in mathematics (Dweck, 2008). Importantly, mindsets can be molded. Teachers can promote a growth mindset by directly teaching students that intelligence is malleable and talent can develop through effort; publically valuing challenge, effort, and mistakes; praising students' processes and not just right answers; and providing meaningful feedback (Dweck, 2008).

Instructional moves can promote motivation to learn. Fourth, several instructional practices are posited to promote student motivation to learn. A class that promotes a learning goal orientation, for example, will give students authority in solving problems and contributing ideas, as well as hold students accountable for disciplinary norms (Engle & Conant, 2002). Similarly, student motivation is supported by sense-making and personal meaning, which in turn

requires that students have opportunities to discuss and collaborate with other students and multiple routes to appear and feel successful (Turner & Meyer, 2009). Positive teacher-student relationships are also important (Middleton & Jansen, 2011, Turner & Meyer, 2009), especially for developing long-term motivation to learn mathematics. Students need both cognitive support, such as availability of relevant resources (Engle & Conant, 2002), and affective support (e.g., enthusiasm, addressing anxiety) from teachers (Turner & Meyer, 2009).

Motivation is situated with tasks as well as cumulative. Finally, on one hand motivation is situated and related to specific activities (Middleton & Jansen, 2011)—that is, motivation to learn is related to individual tasks in which students participate. Nyman and Emanuelsson (2013) posited that students develop and express mathematical interest in tasks and activities and interest can be researched as such, not just as a psychological state. Accordingly, Jansen (2006) argued for a shift toward “focusing on dispositions to engage in particular tasks rather than on learning or doing mathematics generally” (p. 424). Motivation and education research suggests that motivating aspects of tasks include being appropriately challenging (e.g., Copping, 2012; Middleton & Jansen, 2011; Middleton & Spanias, 1999; Turner & Meyer, 2009) and involving some level of choice (Engle & Conant, 2002; Middleton & Jansen, 2011). On the other hand, Middleton and Jansen (2011) argue that these localized experiences with individual tasks are cumulative, and build into long-term motivational patterns.

Linking motivation and engagement. Both within and outside of mathematics education, research shows that certain motivational factors influence student engagement (e.g., Greene, Miller, Crowson, Duke, & Akey, 2004; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003; Skinner, Furrer, Marchand, & Kindermann, 2008). For example, in a study of 805 children in 4th through 7th grade, Skinner et al. (2008) found through students’ self-reports

that perceptions of autonomy was directly related to engagement. Another study of 526 high school students employing the Experience Sampling Method and based in flow theory found that student engagement was significantly affected by the balance between the challenge posed by the task and possession of necessary skills, perceived control over the activity, and relevance of the task (Shernoff et al., 2003). Likewise, a survey study on high school students' attitudes toward mathematics showed that student engagement was predicted by learning goals, a desire to please the teacher, and perception of future consequences of learning mathematics.

Two studies (Jansen, 2006, 2008) have investigated the relationship between motivation to learn mathematics and engagement in mathematics classrooms in more depth. Based on classroom observations and student interviews, Jansen focused on participation in whole-class discussions, which is a subset of behaviors characterized as cognitive engagement. She found that students' motivational beliefs constrained or supported their participation (Jansen, 2006). Students with constraining beliefs associated high risk with participating in whole-class discussions and expressed that they learned mathematics best through listening to the teacher and their peers. These students would participate, however, to help their classmates or to follow class norms (2006), though they contributed mainly procedural explanations (2008). Students with supporting beliefs communicated they were less afraid to make mistakes and did not associate participating with social risk; rather, they participated to learn mathematics. These students participated mainly to display their competence and to support their own learning (2006), and offered more conceptual contributions (2008). This research begins to unpack the relationship between motivation and engagement in mathematics classrooms, and also support the argument that motivational factors underlie student engagement.

Empirical Research on Motivating Instructional Practices in Mathematics

Stipek et al. (1998) conducted one of the few existing studies explicitly drawing on both motivation and mathematics education constructs. They investigated how instruction influenced student motivation to learn mathematics—specifically, instructional practices recommended by both motivation literature and mathematics education literature (e.g., NCTM, 1989, 2000). The instructional practices studied included displaying positive affect and enthusiasm, allowing students to work autonomously, emphasizing learning and effort, and supporting students in taking risks. Motivation outcomes studied were focusing on learning in addition to getting correct solutions (i.e., a learning orientation versus performance orientation), self-confidence, willingness to take risks, enjoyment, and positive emotions related to task. Three groups of upper elementary teachers were studied via observations, student and teacher reports, and surveys. The results suggested that learning orientation and positive affect in the classroom positively affected student motivation to learn, while differential treatment of students based on achievement negatively affected motivation. In fact, positive affect had the greatest effect on students' learning goal orientation, help seeking behaviors, and positive emotions.

Until recently, few other studies explicitly and systematically investigated motivation outcomes in mathematics classrooms, specifically what instructional practices support motivation to learn. Middleton and Spanias (1999) wrote,

“[t]he research on motivational variables in mathematics education has been primarily descriptive and inadequately conceptualized. Often motivation has been thrown “into the pot” to add a little spice to studies originally focused on other factors—such as mathematics achievement... In addition, measurement procedures have been primarily atheoretical and poorly defined.” (p. 83)

In 2011, however, NCTM published a collection of writings on motivation in the mathematics classroom, a few of which reported empirical results of small-scale studies. These studies

confirmed some of the themes previously discussed. For example, one study found that high-achieving females reported being motivated to pursue mathematics because of prior success (e.g., being identified for advanced classes or earning good grades), alignment with personal goals, the nature and challenge inherent to learning mathematics, and relationships with peers, teachers, and parents (Soto-Johnson, Craviotto, & Parker, 2011). Another study drew on expectancy-value theory and found that students reported being motivated to participate in small group work because of its utility value. It helped to learn the mathematics and develop social skills and autonomy by encouraging mathematical reasoning and communication (Jansen, 2011). A third noteworthy study identified four factors that supported students in becoming persistent, flexible problem solvers with a growth mindset—aspects of motivation and disposition to learn mathematics: a) opportunities to work on tasks allowing for multiple entry points and learning styles, b) respectful and clear mathematical communication, c) emphasis on effort as a path to mastery, and establishing a community that valued challenge (Suh et al., 2011).

Turner and Meyer (2009) argued that motivation research from an educational psychology perspective has focused on “whys” of motivation with research to support theory. They encouraged researchers to: a) consider how motivation is influenced in specific learning situations, b) keep close ties between mathematics—especially the unique and specific characteristics of mathematics learning—and motivation outcomes, and c) consider the underlying particulars of how and why math classrooms influence student motivation to learn. In that light, contextual tasks serve as a specific type of learning situation in mathematics classrooms that can generate specific instructional moves (Wernet, 2011), thus warranting investigation into their motivational potential.

Linking Contextual Mathematics Tasks and Student Motivation

Curriculum developers, mathematics teachers, and mathematics education researchers have written about contextual tasks as promoting engagement and student motivation to learn mathematics. Yet, as Middleton and Jansen (2011) argued, problem contexts have the potential to motivate and *demotivate* students, pointing toward the complexity I address in this study. Generally, clear theoretical grounding for claims regarding the relationship between contextual tasks and motivation or engagement has been lacking, though. Also, studies specifically focused on contextual problems have investigated more cognitive outcomes such as student performance on the task and learning outcomes, not the role of such problems in promoting interest or engagement. Few studies have directly investigated the motivational benefits of contextual mathematics tasks, linking motivational theory with instructional practices. In the study by Stipek et al. (1998) described above, for instance, the authors identified the use of multi-dimensional real-world tasks as a potentially motivating practice in the math education and motivation literature, but did not include it as a variable in the study.

In this section, I first describe theoretical perspectives that may inform the use of contextual tasks in mathematics classrooms. I consider theory that supports the motivational potential of contextual tasks as well as theoretical arguments that problematize the use of contextual tasks to motivate students to learn mathematics. Then, I present results from empirical studies relating contextual tasks with motivation and engagement. Two studies systematically and directly linked contextualization of mathematics with student motivation, and several qualitative studies supported the use of contextual tasks to motivate students, though these findings were often peripheral to the core research questions. Finally, I discuss empirical results that challenge the motivational potential of contextual tasks in mathematics.

Theoretical Support for Contextual Tasks as Motivators

Three different theories (among probable others) suggest the theoretical potential of contextual tasks to motivate students to learn mathematics: expectancy-value, interest, and identity theory. First, *expectancy-value theory* holds that achievement motivation—choice, persistence, and performance—can be explained by a person’s expectation for success in an activity and the value they place on the reward that comes with success (Brophy, 2004; Wigfield & Eccles, 2000). The value aspect of the theory in particular supports the use of contextual tasks to motivate students because it addresses the belief in the usefulness and personal relevance of the content (Wigfield & Eccles, 2000) and “awareness of its role in improving the quality of our lives” (Brophy, 2004, p. 133).

Interest theory provides a second foundation for considering the relationship between contextual tasks and motivation. *Interest* is defined to be “the psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time” and has both cognitive and emotional aspects (Hidi & Renninger, 2006, p. 112). With respect to mathematics education, the classes of objects, events, or ideas to which Hidi and Renninger refer are the mathematics content. Through this theoretical lens, multiple types of contexts could promote student motivation to learn mathematics. Contexts that are realistic and familiar or otherwise connect to students’ nonmathematical interests could promote student engagement through their relevance, but interest theory also provides grounds for using any context that might surprise students or elicit other emotional responses. Interest theory, for instance, supports the motivational potential of imaginative, whimsical, or otherwise unrealistic contexts because they can serve to catch students’ attention and support initial engagement in a task.

Third, identity theory provides a sound theoretical base for explaining student motivation through a sociocultural perspective. Sfard and Prusak (2005) define *identity* to be the “stories about a person” that are negotiated between the person and others (p. 14). More specifically, *mathematics identity* refers to “the dispositions and deeply held beliefs that individuals develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives” (Martin, 2007, p. 150).

Identity theory supports the use of contextual tasks in the mathematics classroom as effective motivators because of their potential to blur the lines between everyday and school mathematics knowledge (Nasir, Hand, & Taylor, 2008). Contexts that are of immediate personal relevance to students—especially community-based contexts like those developed around students’ funds of knowledge or social justice issues—can validate students’ identities by connecting mathematics to familiar and personal experiences while increasing their mathematical content knowledge, and incorporating new mathematical activity into their identities (Nasir, Hand, & Taylor, 2008). Broadening the mathematical activity that is part of their identity may lead to greater persistence in mathematics and influence their future choice to participate in it.

These theories speak to motivation to learn, as opposed to motivating students to do well in mathematics class generally, by emphasizing content. That is, the emphasis is not strictly on performance, enjoyment, or extrinsic reward. Expectancy-value theory stresses appreciating the worth of learning specific topics (Brophy, 2008), and interest theory suggests that mathematics becomes a personal interest when students value the content, pose curiosity questions about topics, and persist in efforts to learn (Hidi & Renninger, 2006). All three theories suggest that making the content meaningful and relevant, linking it to other important aspects of students’ lives, will support their motivation to learn.

Theoretical Objections to Contextual Tasks as Motivators

Some scholars have problematized the use of contextual tasks in the curriculum and have called for a reconsideration of their role in the curriculum (e.g., Gerofsky, 2004; Verschaffel et al., 2000). There are two main arguments that challenge the motivational potential of contextual tasks. The first is philosophical—that contextual tasks cannot ever truly reflect students’ real-world experiences. The notion of “the real-world” itself is problematic because it is difficult to capture or agree on a definitive meaning (Gerofsky, 2004; Thomas & Gerofsky, 1997). Gerofsky (2004) argued that rather than reflecting students’ “real lives,” word problems reflect the nature of other word problems. Thus, students approach contextual tasks with firmly entrenched beliefs and expectations about how to solve them as rote applications of algorithms (Verschaffel et al., 2000). This suggests that contextual tasks are unlikely to support meaningful connections between school and everyday mathematics or communicate the value of mathematics.

Second, the suggestion that contextual tasks can serve to motivate students to learn mathematics simplifies students’ diverse experiences and interests (Boaler, 1993; Chazan, 2000; Sullivan et al., 2003). Chazan (2000) wrote, “finding problem contexts that are ‘real’ for a class full of students on a range of different trajectories seems unrealistic” (p. 55). If contextual tasks repeatedly fail to relate to students’ experiences and goals, they may in fact alienate or exclude some students, and result in students disengaging from mathematics (Middleton & Jansen, 2011; Sullivan et al., 2003). Sullivan et al. (2003) argued that teachers need to be aware of how certain contexts can exclude marginalized students and work to be explicit about the connection between the context and mathematical content. This stresses the importance of contexts that are personally relevant or fit with students’ broader identities, and highlights the difficulty in developing contexts that will motivate broadly diverse populations of students.

Other scholars have argued that too much emphasis on contexts and application could detract from other aspects of mathematics (Otten, 2011; Sinclair, 2001; Wu, 1997). They challenge not so much potential of these tasks to motivate and engage students, but the extent to which they should be used for this purpose. For instance, although Wu (1997) acknowledged the necessity for some inclusion of applications in school mathematics he posited that disproportionate attention to applications threatens students' opportunity to cultivate "intellectual appreciation of [the] structure and cohesion" of mathematics (p. 948). Similarly, Otten (2011) encouraged mathematics teachers not to feel as if they needed a real-life context ready for every topic. Too much focus on the utility value of mathematics, he wrote, detracts from some other aspects of the subject, such as mathematical processes, the historical significance of mathematics as a human achievement, and the intrinsic beauty of the subject.

An extant body of literature focuses on the *aesthetics of mathematics*, defined by Sinclair (2004) to be the potential to combine information and imagination to derive meaning and pleasure from doing mathematics. Research on mathematicians and the role of aesthetics (e.g., Wells, 1990) shows that although few precise patterns exist in what they find the most "beautiful," mathematicians generally found certain ideas, proofs, and problems to be aesthetically pleasing, with simplicity, brevity, and surprise recognized as aesthetically pleasing. Based on the experiences of mathematicians, Sinclair (2004) argued that in addition to serving evaluative and generative roles, there is a motivational aesthetic of mathematics related to interest, values, and emotion. The specific categories of aesthetic motivation Sinclair proposed were visual appeal (or simplicity and order), sense of surprise, and a social dimension. Sinclair extended this idea to school mathematics, positing that aesthetically rich mathematics learning environments—those that connect to innate human sensitivities and activities—can be

motivating for students (2001), though students with different goal orientations may respond differently in these environments. She encouraged teachers to elicit and use students' intuition and affective responses to mathematical tasks (2004).

The issues raised here accentuate the social, cultural, and mathematical complexities involved with using contextual tasks to promote interest and positive mathematical identities among students. Theories supporting the use of contextual tasks to motivate students to learn mathematics may stop short of explaining the nuances of the relationship between contextualization and motivation. Next, I turn to empirical evidence that links contextualization and motivation to learn mathematics.

Empirical Support for Contextual Tasks as Motivators

A review of mathematics education literature yielded only two studies in which researchers directly and systematically investigated the effects of contextual tasks on student motivation. First, Cordova and Lepper (1996) investigated how contextualizing and personalizing mathematics content as well as how provision of choice influenced students' intrinsic motivation, level of engagement, achievement, perceived competence, and level of aspiration. In the controlled experimental study, 70 fourth- and fifth-graders completed three 30-minute sessions playing a specially designed computer game intended to teach order of arithmetic operations. The game was contextualized by adding space travel and treasure hunt scenarios; personalized by adding students' names, the names of their friends, their favorite toys, and so on based on preliminary surveys; and choice was added by allowing students to choose images and characters. Students were split into five groups: 1) a control group, 2) general contextualized with choice, 3) general contextualized without choice, 4) personalized contextual with choice, and 5) personalized contextual without choice.

Contexts, personalization, and choice significantly (all $p < 0.05$) influenced each of the five dependent variables (Cordova & Lepper, 1996). In most cases, students experienced greater motivation and engaged in more challenging forms of play (suggesting motivation to learn) when the content was put in imaginative contexts, and these effects were increased when the context scenario was personalized. Therefore, the study supported the use of contextual mathematics tasks—particularly with personalized contexts—as a means to promote student engagement with and enjoyment of specific tasks. There is, however, a question about the influence of novelty in this study. Over time, the task could become habitual and the effects of contextualization, personalization, and choice may diminish. Brophy (1986) argued, for example, that focusing on intrinsic motivation to learn mathematics is problematic because the source of motivation may lie in features of the task or its implementation (e.g., use of computers, game like nature of the task) rather than engaging in the content itself. Also, this study came out of the educational technology literature, and may have limited generalization to contextual mathematics tasks outside a computer environment.

A study by Ku and Sullivan (2000) in Taiwan did confirm Cordova and Lepper's findings related to the personalization of contexts in a traditional classroom environment. Drawing on interest theory, they performed an experiment with 5th-graders in which students in a treatment group received instruction with personalized contexts. The authors reported that students in the treatment group indicated significantly more positive attitudes and higher motivation related to the lessons and tasks than the control group. One strength of this study was that it was completed in the students' classrooms rather than the computer environment used by Cordova and Lepper; another was the development of a group personalization technique where textbook word problems were modified according to the most common interests and experiences communicated

by students at the class level. Its primary weakness was only basing the measure of student motivation on a few Likert scale survey questions, not students' actual engagement in the classroom through observation or teacher reports. Also, levels of intrinsic motivation (how much students liked or were interested in the lessons) were captured rather than motivation to learn.

Some qualitative studies have also positively linked contextual tasks in mathematics with student motivation (Jansen & Bartell, 2011; Mitchell, 1993; Nicol & Crespo, 2005; Weist, 2001), though most of these studies are only loosely grounded in motivation theory and were not systematic studies of the effects of contextualization on student motivation. Results from self-report surveys and interviews with 4th- and 6th-grade students suggested that the students generally “liked” fantasy and children’s real-world problems (versus adult real-world problems), and they solved fantasy problems with as much or more success as on real-world problems (Weist, 2001). Students’ interest and preferences, however, depended not just on the problem categories, but also on specific problems, suggesting that students tune in to individual contexts. Through focus groups and open-ended questionnaires of high school mathematics students, Mitchell (1993) tested his interest model and found that students reported meaningfulness to be an important element in sustained situational interest. This finding was further supported by a follow-up quantitative study using interest surveys. The study did not directly address the effect of contextualization, but did provide evidence that students themselves report increased interest when content links to their everyday lives, which is one purpose of using contextual tasks.

Other studies include cognitive or behavioral engagement outcomes. Through classroom observations, Nicol and Crespo (2005) found that mathematics tasks with imaginative contexts promoted intellectual and emotional engagement and persistence in the tasks for two different groups of students—preservice elementary teachers and middle school students. To measure

engagement, the authors captured instances of students enthusiastically participating in activities, seeking challenge, and offering unsolicited mathematical ideas. In another study of middle school students' beliefs about characteristics of caring mathematics teachers, some students identified meaningful contextual tasks as interesting, especially when they can relate to them (Jansen & Bartell, 2011). One student, contrary to Nicol and Crespo's (2005) and Weist's (2001) findings, said that she did not like imaginative contexts, preferring realistic contexts based on adult experiences. In their study intended to operationalize cognitive engagement, Helme and Clarke's (2001) initial findings suggested that novel contextual tasks that were personally meaningful promoted two eighth-grade students' cognitive engagement.

Similarly, a few studies outside of mathematics education suggest that relevant and authentic contexts promote student engagement (Buck, Beeman-Cadwallader, & Trauth-Nare, 2012; Copping, 2012; Mitchell & Carbone, 2001; Rivet & Krajcik, 2008). Based on 100 reports written by high school teacher-researchers who implemented self-developed tasks intended to promote quality engagement, Mitchell and Carbone (2011) developed a "typology of task characteristics" that promote student engagement. They identified eight dimensions of engaging tasks, including an artificial-authentic dimension. The teacher reports suggested that more authentic tasks "generate engagement as it is easier for students to perceive either importance for or relevance to their current or future life" (p. 264). Similarly, studies in science education indicate relevance is an important factor in student engagement. The results of an investigation of 7th-grade girls' experiences in problem-based learning in a science unit suggested that authentic contexts were one factor of science learning environments that supported girls' cognitive engagement (Buck et al.; 2011). Rivet and Krajcik (2008) found a strong correlation between students' attention to contextual features of science tasks and their achievement through

classroom observations and assessments. The authors attribute this relationship to both the anchors provided by contexts related to students' prior knowledge and experiences, and the role of contextualizing science instruction in motivating and engaging students in the learning process. Based on data from video observations, interviews, journals, and surveys from a study in which he served as teacher-researcher, Copping (2012) proposed that one aspect of teaching that supports an effective learning environment in science is a meaningful curriculum that is aligned with student experiences. The results of these studies support the hypothesis that contextualized tasks can promote student engagement. However, these conclusions drawn from research in science or other subject areas—which, by their nature may be easier to connect to students' everyday experiences—may not be generalizable to contextual mathematics tasks, which as discussed elicit distinctive beliefs and emotions in the mathematics classroom.

A few other studies involving context-rich curricula (e.g., CMP, teaching mathematics for social justice) suggest that contextual tasks promoted student motivation, but evidence from these studies is largely anecdotal. Lubienski (2000), for example, worked as a teacher-researcher in a 7th-grade CMP classroom, studying differences in students' interactions with the curriculum based on socio-economic status. She reported that realistic contexts were “effective motivators, prompting students to delve into the problems” (p. 476). This description seems indicative of cognitive engagement, but it was a peripheral finding in her research.

Gutstein (2003) used both the written MiC curriculum and problems he developed as part of TFSJ in his classroom. He found that the students thought MiC problems were interesting, but not particularly relevant, and he reported that students were more interested in the projects he designed than the MiC contexts. He argued,

Through their practice of reading the world with mathematics, the students began to change how they felt about mathematics. Although not all loved math, virtually all

understood that mathematics was a tool not only to solve both realistic and fanciful, sometimes enjoyable, problems in books, but it could also be used to dissect society and understanding equality. (Gutstein, 2003, p. 67)

Through an identity theory lens, students' recognition of mathematics as something that can serve to change their community or larger society may support their motivation to learn it. Like Lubienski, however, this claim was made without significant supporting evidence because it was not the focus of the research. Gutstein (2007a) also argued that students continued to think about and discuss the real-world projects after class. He wrote, "Although I am not completely clear why, and unfortunately did not ask systematically, this project deeply engaged students. I believe that it was because it tied into their aspirations, experiences, community issues, and sense of justice" (p. 61). This statement reflects the anecdotal nature of reports on the relationship between context and student engagement and motivation to learn mathematics.

Empirical Challenges to Contextual Tasks as Motivators

Extant empirical evidence from a sociocultural perspective suggests that contextual tasks are not necessarily effective in engaging or motivating students to learn mathematics—or more precisely, that as Boaler (1993) and Chazan (2000) suggested, it is a complicated relationship. As a teacher-researcher in a high school, low-tracked, task-based algebra course, Chazan (2000) found that student engagement was highly variable and followed no particular pattern. Students occasionally disengaged from contextual tasks designed uniquely for the class, but would be highly engaged in more abstract tasks. "Buy-in" from student leaders in the class seemed to have far greater influence on student engagement than the contextualization of the content.

Brantlinger (2007) argued that claims are often made about the relationship between culturally relevant mathematics curricula and motivation to learn for students of color, but these claims are not grounded in ample empirical evidence. His dissertation work aimed to address this

lack of empirical testing. Through practitioner research in which he used reform pedagogy (including the use of more contextualized tasks), Brantlinger found that student engagement increased over time in the course. Engagement was measured by the number of elaborate student contributions, level of resistance, and reliance on teacher help. While some students showed markedly increased engagement in lessons with social justice tasks, others resisted. His report provides valuable evidence that tasks drawing on social justice contexts can be engaging for some students, but not all. It remains unclear why certain students resisted and others showed higher levels of engagement. Also, it is impossible to separate the effects of reform pedagogy in general and the specific influence of contextual tasks.

Bevil (2003) conducted a quasi-experiment with 320 students in grades six through eight to investigate the effects of the use of real-world applications and academic status on student achievement and perceptions of the classroom environment. Two scales on the survey to measure student perceptions are of particular relevance—personal involvement in class and satisfaction—as both serve as measures of student motivation. Treatment consisted of one semester taught from an applied curriculum developed by Bevil in regular classroom settings. Bevil found that the emphasis on real-world application tasks only significantly influenced student perceptions of their personal involvement and satisfaction for high-achieving students, who may have been bored with the traditional classroom. One weakness of the study was the dependence on students' self reports. Also, like the Brantlinger (2007) study, it is difficult or impossible to differentiate between the effects of contextual tasks and other factors like the higher cognitive demand of the treatment tasks and use of cooperative groups.

Synthesis

In sum, there is empirical evidence to support both sides of the theoretical debate regarding the relationship between contextual tasks and student engagement and motivation to learn mathematics. Yet, few studies have directly and systematically investigated the relationship between contextual tasks in mathematics and motivation and engagement—much of the research considered the variables peripherally or reported findings anecdotally. Furthermore, most of the studies reviewed here lacked a strong theoretical foundation and/or did not draw on expectancy-value, interest, or identity theory, which as discussed above, could provide theoretical grounding to make sense of how contextual tasks can motivate students.

There is evidence to suggest that contextual tasks can and do promote student engagement in mathematics, but under certain circumstances that are not quite clear. Middleton and Jansen (2011) wrote,

We often think that story problems involving contexts from life outside school promote connection to mathematics and opportunities to make sense of mathematics. Story-problem contexts can achieve these goals, but only under certain conditions. Sometimes contexts can interfere with understanding and lead to disengagement! (p. 107)

They suggest that the type of context and instructional support, such as using contexts that are personally meaningful and culturally relevant can influence student engagement, but these arguments are based largely on theory, not empirical evidence.

There are several complex variables involved when considering engagement, motivation, and contextual tasks. First, there is the curriculum in which the contextual tasks exist. Tasks in NSF-funded, Standards-based, nationally published curricula (e.g., CMP; *Mathematics in Context*, National Center for Research in Mathematical Sciences Educational Staff, 1998) and curricular programs used on a smaller scale intended to increase diverse participation in mathematics by connecting students' everyday and school mathematical knowledge (e.g., TFSJ)

have sought to create new genres of contextual tasks by: a) putting contextual tasks at the center of instruction, b) making them more complex so the context is an integral part of solving, c) making them more personal for students by drawing on community funds of knowledge, and/or d) explicitly addressing issues of power and equity. By breaking the traditional rules of story problems, one aim of these tasks is to motivate students to learn mathematics in ways canonical contextual tasks do not.

A second variable is the type of context—imaginative/whimsical versus realistic, personalized versus non-personalized, and contexts relevant to students' immediate lives versus contexts drawn from adult activities. Additionally, contexts may draw on community-based knowledge or social justice issues. Third, like any other task, teachers implement contextual tasks in different ways, and different instructional practices may influence student engagement with them (Chapman, 2006; Middleton & Jansen, 2011; Nisbet et al., 2007; Wernet, 2011). Generally, more empirical research is needed that directly investigates the hypothesized relationship between contextual tasks and student motivation. This study addresses the issues discussed regarding the nuances of contexts and motivation, grounded in expectancy-value theory to allow more robust interpretations of results.

Research Questions

Through exploring the relationship between contextual tasks and student motivation, I hoped to provide a better understanding of what types of contexts and which instructional practices relate to higher (or lower) levels of engagement and motivation. Toward this end, the following questions guided the design and implementation of the study:

How does the use of contextual tasks in middle school mathematics classrooms relate to students' engagement in the tasks and motivation to learn mathematics?

- What characterizes the contextual tasks as written (e.g., personalized, community-based, levels of authenticity and centrality) in lessons during which students show particularly high and low levels of engagement?
- What characterizes the enactment of contextual tasks, including instructional practices (e.g., positioning, elaborating, referencing) and student attention to context, in lessons during which students show particularly high and low levels of engagement?
- What factors of motivation (e.g., valuing content, enjoyment of task, alignment with goals) underlie student engagement relative to the contextual tasks used in class?¹

The first two questions address the relationship between contextual mathematics tasks and student engagement in individual lessons. Building on extant studies suggesting that student motivation influences engagement in specific learning scenarios (Jansen, 2006, 2008), the third question was included to explore more deeply students' experiences in lessons relative to their expressed levels of motivation to learn and motivation-related beliefs about mathematics.

Theoretical Foundation—Expectancy-Value Theory

As previously discussed, several theories exist that help explain and predict the relationship between contextual tasks and student engagement and motivation to learn mathematics. For this study, I chose to use expectancy-value theory because of its specific focus on students' beliefs about various aspects of valuing the content—mathematics, in this case—for

¹ These research questions differ from those originally proposed. Rather than the first question being about highly engaging lessons and the second being about low-engagement lessons, I split the content of the questions so the first is about the tasks as written across the noteworthy lessons and the second is about the tasks as enacted. I made this change to set up the structure of the chapters after the study was complete, so it did not change the purpose or nature of the proposed study. Further, the word “enactment” replaced “implementation” to better reflect the focus on both the teachers' instructional practices (e.g., positioning, elaborating, referencing) and student attention to context.

its own sake. *Expectancy-value theory* holds that achievement motivation—choice, persistence, and performance—can be explained by a person’s expectation for success in an activity and the value they place on the reward that comes with success (Brophy, 2004; Wigfield & Eccles, 2000). The theory grew largely out of work in mathematics classrooms (Turner & Meyer, 2009). *Expectancy* involves beliefs regarding one’s current competence and future ability in a particular activity. The *value* one assigns an activity has several components: a) *attainment value*, or the importance of doing well on a task; b) *intrinsic value*, or level of enjoyment; c) *utility value*, the usefulness and correspondence with future plans; and d) *cost*, the level of effort and sacrifice required (Wigfield & Eccles, 2000). With respect to mathematics education, a student’s willingness to work on a particular task is a product of their belief in their ability to successfully complete the task and how much they value the task. Similarly, a student’s motivation to participate in and use mathematics throughout their lifetime is a product of their belief in their ability to learn mathematics and how much they value the subject in general.

Brophy (1986) argued that expectancy-value theory is a promising theory for making sense of motivation to learn mathematics in particular. Unlike other motivation theories, it focuses attention on the mathematical *content* rather than other features of tasks, such as their social affordances or game-like qualities. In other words, students’ motivation to learn should arise from the mathematics and the intended learning. As discussed previously, it was a reasonable theoretical foundation for this study because it supports the hypothesis that contextual tasks can promote student motivation by highlighting the value of the mathematics. It also provides a useful framework for analyzing student responses in order to answer the third research question, regarding factors of motivation underlying their engagement in contextual tasks.

CHAPTER 3

METHODS

The purpose of this study was to gain a more nuanced understanding of the conditions under which contextual tasks do (or do not) engage and motivate students to learn mathematics. In this chapter, I will describe how I identified the extent to which 7th-grade students were engaged during lessons observed over the course of one semester, and how I determined the nature of contextual tasks and their implementation in these lessons. Further, I will describe how I used surveys and interviews to identify themes in student motivation to learn as it related to students' engagement in contextual tasks. The next section includes a general description of the research strategy used and a rationale of the methodology.

Research Strategy

Fredericks et al. (2004) argued for more qualitative studies on student engagement to accomplish specific goals: a) to focus on how students experiences the complexities of the school environment, b) to highlight why students might choose to disengage and how the different types of engagement are related, and c) to address individual and group differences. A qualitative study is appropriate to accomplish these goals and answer the research questions because it allowed for a more in-depth perspective through multiple data sources, including the voices of students themselves, on the relationship between contextual tasks and student engagement in mathematics classroom. Drawing on multiple data sources was a central aspect of the research strategy, both to offer more validity and reliability to the findings through triangulation and to address issues with limited data sources in extant literature on school engagement (Fredericks & McCloskey, 2012; Middleton & Spanias, 1999, Turner & Meyer, 2009). These issues will be discussed throughout this chapter to support particular methodological choices.

The general approach of the study was to conduct a multiple-case study, where I define the cases to be middle school mathematics lessons in two 7th-grade classes. Case study is characterized as “particular, descriptive, inductive, and ultimately heuristic” (Stark & Torrance, 2005, p. 33), making it an appropriate strategy for gaining rich and varied perspectives on the relationship between the variables of interest. This approach was well-suited for this study because extant research indicates multiple complex factors, including a variety of instructional practices, influence student motivation to learn mathematics (e.g., Middleton & Jansen, 2011; Middleton & Spanias, 1999; Turner & Meyer, 2009). Case study allowed the necessary in-depth, detailed investigation of student motivation related to solving contextual mathematics tasks.

I had 28 cases of middle school mathematics lessons in two 7th-grade classes that used a problem-based curriculum. The curriculum included a variety of contextual tasks in terms of type, centrality, and authenticity of contexts. These constructs will be described further below. These cases allowed me to study how task characteristics relate to student engagement and motivation to learn mathematics across classrooms. My aim was to isolate to the extent possible the influence of contextual tasks and their implementation, and minimize the influence of other pedagogical or curricular factors. Thus, it was appropriate to study a small number of classrooms using the same curriculum and look for themes, not comparisons, across classrooms. We also know that teachers’ practices are fairly consistent in terms of pedagogy and lesson structure (e.g., Ho & Kane, 2013), which also supports the ability to consider and compare across lessons the influence of specific tasks on student engagement and motivation within each classroom. Another important part of the research design was the opportunity to observe variation in the type of tasks assigned, the content covered by the tasks (e.g., algebra, geometry, numbers and operations), and in the implementation of the tasks. I chose to study two classrooms and spend

ample time in each in order to develop a richer understanding of the students and environment. Further, to support the correlation of the results of observations of student engagement with the teachers' and students' perceptions, I needed an adequate number of observations for each classroom. More than two classrooms would mean less time in classrooms and with students. The benefit of two classrooms over one was access to more students with more diverse experiences in and out of the classroom. It also provided an internal means to check the data to see if themes extend beyond one classroom.

Setting and Participants

The first criterion for selecting participating schools was the use of the Connected Mathematics Project curriculum throughout the middle grades, because it is problem-based with ample contextual tasks of various types (Lappan & Phillips, 1998; Lappan et al., 1997). Thus, I could safely assume that students would have opportunities to engage students in contextual tasks in a majority of daily lessons, limiting the effect of novelty on student engagement, and increasing the likelihood of observing the implementation of a diverse range of contextual tasks. Second, I recruited teachers of 7th grade classes because of the varied content in the 7th-grade curriculum, including algebra, geometry, and numbers and operations (CCSSI, 2010; Lappan et al., 2006, 2014). Third, participating teachers needed experience teaching CMP and followed the curriculum closely in terms of tasks and philosophy, without much supplementing (e.g., with more procedural materials). Two teachers in two different districts—Mrs. Meyer at Pine River Middle School and Mrs. Cole at Southpoint Junior High School--fit these criteria. They were recommended as participants by knowledgeable others, including faculty with experience working with local teachers and CMP development staff.

To select participating classes, I consulted with the teachers to identify classes meeting certain conditions. I wanted classes in a general mathematics track that covered content required by all students to increase the likelihood of students having diverse mathematical experiences and levels of motivation. That is, I wanted to avoid classes in which students were tracked into advanced (e.g., Algebra 1) or remedial classes. Both teachers had 7th-grade classes in a fourth hour class, allowing for focus group interviews to take place during lunch immediately after class. I met with participating classes during the second week of the school year to introduce myself, inform students about the nature and requirements of the study, and distribute consent and assent forms. Students and their parents could consent individually to participate in the surveys, interviews, and be included in observation videos.

Through analyzing students' initial motivation and belief surveys and consulting with the teachers, I used purposeful selection to identify six focus students in each class. Selecting six focus students was consistent with other studies on motivational beliefs and students engagement in secondary classrooms employing observations and/or interviews (e.g., Jansen, 2006, 2008; Rivet & Krajcik, 2008). Attending to the same small group of students throughout the study allowed for more consistent comparison of students' engagement across classrooms. My goal was to select students who represented diversity in terms of their motivation to learn mathematics, prior success in mathematics, and interests; and who would work reasonably well together for classroom activities and focus group interviews. That is, I wanted groups that were representative of the class as a whole, avoiding any interpersonal issues or conflicts that would influence their learning when working together or influence their responses during interviews. Mrs. Meyer and Ms. Pearson consistently grouped the focus students together for small group work during the observed lessons.

Pine River Middle School²

The first site, Pine River Middle School, is a rural school located in a small town in the Midwest. It serves students in grades six through eight. A summary of the size and demographics of Pine River is contained in Table 1. Pine River is an original CMP school; they have used the curriculum since 1990. At the time of the study, the school was transitioning from the second to the third edition of CMP (copyright 2014). During the study period from September to January, the 7th-grade at Pine River worked on the units *Shapes and designs: Two dimensional geometry*, *Accentuate the negative: Integers and rational numbers*, and *Stretching and shrinking: Understanding similarity*. Each class period was 60 minutes long.

Mrs. Meyer. Mrs. Meyer was in her 8th year of teaching and had been at Pine River for four years. She has taught the CMP curriculum all eight years in grades six through eight. Through classroom observations and many informal conversations with Mrs. Meyer, it was clear she had a commitment to student inquiry and attending to and building on student reasoning. The class was organized into “teams” of 4-6 students who sat together at tables, and students were encouraged to work together and talk with each other about the mathematics in every lesson. When a student posed a question, she would often respond by asking the student to talk to others in the group before working with them one-on-one. Mrs. Meyer followed the CMP curriculum closely and never supplemented with other materials during my observations other than to pilot one open-ended task for another curriculum project. She did occasionally modify lessons in terms of how long she spent on each one or specific supports and extensions provided. In a typical lesson, Mrs. Meyer followed the standard “launch, explore, summarize” pattern of a CMP lesson. She launched the problem for the day, gave students five minutes to work individually,

² All school, teacher, and student names are pseudonyms.

opened the lesson to working in small groups, then facilitated a summary discussion with the whole class. The launches often started with students talking about what they had done in the previous lesson in their small groups, a guiding “focus question” from the CMP teacher materials, and curriculum-provided launch videos when available.

Students in Pine River participating class. There were 22 7th-grade students in Mrs. Meyer’s fourth hour mathematics class. Four students were excluded from the study because of missing forms assent or consent forms. Mrs. Meyer voiced concern early in the school year about the “struggles” she felt with the class in terms of meeting learning objectives at the same pace as her other classes (personal communication, October 29, 2013). Overall, the students worked well together and there were few behavioral disruptions I observed. Mrs. Meyer believed the difficulties stemmed from the varied academic profile of the class. Of the 22 students, nine were enrolled in “math lab,” meaning they had an extra math hour with an academic aid. Those students had Individual Education Plans or 504 plans, having been diagnosed with learning disabilities, ADHD, and/or other health impairments.

Table 1

School Demographics³

Site	Total students	% Students of color	% White students	% Eligible for free/reduced lunch
Pine River Middle School	448	4.5	95.5	30.6
Southpoint Junior High School	951	33.7	66.3	39.4

³ Demographic information was accessed from www.mischooldata.org and https://www.michigan.gov/cepi/0,1607,7-113-21423_30451_36965---,00.html on April 16, 2014.

Southpoint Junior High School

The second site, Southpoint Junior High School, is a suburban school located outside a state capitol in the Midwest. It serves students in grades seven and eight. A summary of the size and demographics of Southpoint is contained in Table 1. Southpoint had used the second edition of CMP (copyright 2009) for five years, so the school was newer to the curriculum than Pine River. During the study period, the class at Southpoint worked on material in the units *Stretching and shrinking: Understanding similarity*, *Comparing and scaling: Ratios, rates, percents, and proportions*, and *Accentuate the negative: Integers and rational numbers*. Each class period was 55 minutes long.

Ms. Pearson. Ms. Pearson was in her 9th year of teaching at Southpoint. She taught high school for six years and middle school with the CMP curriculum for three years in grades seven and eight. Ms. Pearson was committed to standards-based assessment and student self-assessment of major learning goals, which were posted around the room on large posters for each unit. She was also working on facilitating student work in small groups and developing group norms appropriate for middle school students. The students sat at desks arranged in rows, which Ms. Pearson communicated helped them focus during whole-class discussions. On the days I observed, students typically moved their desks into established groups of three, though they did not use group work on a daily basis. When in groups, students were occasionally assigned roles (e.g., facilitator, recorder, resource manager) and were expected to talk only to each other.

Ms. Pearson also followed CMP closely and never supplemented with materials from other curricula in the observed lessons. She did use individual white boards for students during unit reviews, and for three of the lessons in the study, she modified the task to be more open-ended and to include student presentations. In these lessons, Ms. Pearson developed and

distributed “task cards” to each group with the modified task and role assignments. For example, she modified the directions for *Stretching and Shrinking* problem 2.3 as shown in Appendix A. In a typical lesson, Ms. Pearson started with going over homework or “learning checks” with the whole class, launched the problem for the day, asked students to work in small groups, then facilitated a summary discussion with the whole class.

Students in Southpoint participating class. There were 23 total 7th-grade students in Ms. Pearson’s fourth hour mathematics class. Three students were excluded from the study because of missing forms assent or consent forms. In general, the class was diverse in terms of performance and participation. Ms. Pearson identified a few boys as particularly high-achieving. They resisted working in small groups during class, preferring to work on their own. She also communicated that due to a variety of issues, including students who were English Language Learners and the range of experiences students had with instruction and implementation of CMP in 6th grade, some students struggled with the language and content demands of the curriculum.

Focus Students

In each class, I selected six focus students for the study based on their expressed motivation to learn mathematics, their interests outside of school, and teacher recommendations. Primarily, I sought to select groups that represented the diversity of the class in terms of their motivation to learn mathematics: their expectations of themselves as mathematics students and how they value mathematics in and out of school. During my second meeting with students, I administered a survey on students’ beliefs and values (see Appendix B), which I will describe in detail in the instruments section below. The survey included questions to capture students’ expectancy for success in 7th-grade mathematics and the extent to which they valued

mathematics. There were also questions related to mindset, but nearly all students communicated a growth mindset, so I did not use that data in selecting focus group students.

In selecting focus group students, I first identified participating students who were low in both expectancy and value, high in both, and students who were low in one and high in the other, hoping to choose two students in each category per class. “Low” was set as less than an average value of five for the appropriate survey questions, “high” was set as five or greater. When more than two students fell into a category, I identified students with a range of interests outside of school. Finally, teachers reviewed the groups of students being considered. In cases in which I was choosing between students, the teachers suggested students with different levels of prior achievement in mathematics and who could work together in class and interviews. In Table 2, I listed the focus group students who participated in the study with some results from the beliefs and values survey.

Data Collection and Instruments

Several researchers have emphasized a need for motivation research in mathematics education that considers students’ self-reports, teacher reports, observations, and/or interviews to counter the trend in which motivation research focuses on self-report and mathematics education research focuses on observation (Fredericks & McCloskey, 2012; Middleton & Spanias, 1999; Turner & Meyer, 2009). This trend is problematic because alone, either approach introduces potential biases and validity problems (Middleton & Spanias, 1999) and provide limited information on student engagement and motivation across lessons and tasks. I used four primary data sources: classroom observations, lesson-specific student surveys, lesson-specific teacher surveys, and focus group interviews. As discussed in the last section, an initial survey on

students' general mathematical beliefs and values served as secondary data to provide baseline information about student motivation to learn mathematics and select focus group students.

Validity of the instruments and data collection techniques was initially addressed through two rounds of piloting the instruments and data collection strategies. I conducted the first pilot in 6th- and 7th-grade classrooms at a small private school in the spring of 2013, and the second in a summer camp program in which students entering 5th and 6th grade engaged in mathematics for social justice activities every day for two weeks. In each pilot, I considered the extent to which instruments allowed access to the data I intended and their utility value in answering the research questions. Based on these experiences, I made some changes to the data collection tools, including: a) refining fieldnote spreadsheets to improve usability, b) deciding when I rated cognitive engagement at a 1 (students appeared cognitively disengaged) I would not give a score for emotional engagement to avoid high engagement scores when students showed positive affect but were talking about non-mathematical topics, and c) fixing or clarifying language students found confusing across the surveys, adding sample responses to the open-ended questions. Generally, the results suggested the lesson-specific surveys were valid. In follow-up interviews, students and teachers talked about the aspects of engagement in the way I intended to capture cognitive and emotional engagement (e.g. how hard they tried, how “fun” the lesson was, the level of cognitive demand of the task). Their responses were also internally consistent; they gave similar and supporting answers regarding their self-assessment of their engagement throughout the subsequent interviews. In the following sections, I describe each data source and more results from checks on validity and reliability as appropriate.

Table 2

Study Focus Students

Student Name	Site	Average Expectancy of Success Response	Average Value Response	Interests	Favorite Lesson	Other Information Provided by Teacher
Felix	Pine River	2.8	3	Skeet shooting, making things out of wood, fishing, knife collecting	Didn't have a favorite—struggled	Was diagnosed with ADHD, has a 504 plan and attends math lab
Drayton	Pine River	4.4	3.83	Lunch, hunting, fishing, eating	Division. It's easy, I like it	New student at Pine River—previously homeschooled
Sophia	Pine River	2.6	5.67	Music, drawing, riding bikes, swimming	Fractions. Easy, fun	Attends math lab
Lilly	Pine River	6	4.67	Reading, writing, cross country, playing clarinet	Graphing, because I liked drawing graphs	
McKenna	Pine River	6.4	5.5	Reading, writing, ice cream, playing oboe, saxophone, and piano	Multiplication the traditional way. It was easier and the teacher explained it well	
Jeff	Pine River	6.8	7	Baseball, basketball, football, hanging out with friends, fishing, watching TV	Long division. It was challenging, and I like to be challenged in things I'm good at	
Lena	Southpoint	1.8	2.67	Reading, writing, playing piano and trumpet, running, talking, organizing	Percent lessons, actually kind of fun	

Table 2 (cont'd)

Emily	Southpoint	3.6	3.17	Cheer, dance, spending time with friends and family	My favorite math lesson from last year was learning how to add taxes onto the total. Because it's something that you use often.	
Jacob	Southpoint	4.4	5.8	Go camping, shoot guns, archery, air soft battles, and sharpening my Bowie knife	Measuring angles and lengths	
Adelyn	Southpoint	4.8	4.5	Reading, writing, drawing, listening to music, going exploring in the woods...pulling pranks, joking around	Learning about fractions. Learning fractions always came easier to me and I loved them since 2 nd grade ☺	
Brianne	Southpoint	3.8	5.33	Reading, roller skating, extra work	All the lessons I understand	
Kim	Southpoint	5	5.83	Softball and winter guard	Plotting points. It was fun	
Elijah	Southpoint	6.4	6.33	Running, soccer, basketball, video games, Science Olympiad, math competitions	My favorite math lesson last year was when we had to find missing dimensions with shapes when our teacher only give me a percent of how big it is compared to the original.	[Elijah] is very task oriented and more concerned about getting his work and homework done than working in a group, figuring things out together, and being further challenged, although he would accept challenging questions.

Note: Brianne was originally selected as a focus student, but left Southpoint in September (after the second observation) and was replaced by Jacob.

Classroom Observations

I collected all data from September 2013 through January 2014. I observed the two participating classes weekly from the third week of school through the end of the first semester. With a break for state testing and schedule changes due to weather-related school cancellations, I conducted a total of 14 observations at each site. Observing provided important data in the study, because it provided a systematic way for me to capture student engagement for comparison across lessons. Fredericks and McCloskey (2012) wrote,

The prime advantage of using observation techniques to study engagement is that they can provide detailed and descriptive accounts of...factors occurring with higher or lower engagement levels. These descriptions enhance our understanding of unfolding processes within contexts. Observational methods also can be used to verify information about engagement collected from survey and interview techniques. (pp. 767-768)

Each observation consisted of one class period, which typically included work on one CMP problem. To the extent possible, I observed on consistent days (Tuesdays at one site and Thursdays at the other) to minimize the possible effect of patterns of engagement through the week (e.g., students might be more engaged early in the week than as they approach the weekend). I did, however, observe three consecutive days at both sites late in the semester to see how student engagement and ideas progressed over an Investigation (these are included in the total 14 lessons per site). Observing weekly also allowed me to see a range of content in the 7th-grade curriculum, including algebra, geometry, and number, and to observe lessons with and without contextual tasks. My role in the observations was as observer-as-participant (Creswell, 2009), because demands on my attention while observing allowed minimal participation in lesson activities, though when students occasionally asked me questions about tasks I would

answer if possible. In the following sections, I describe the specific data sources collected during observations, including written tasks, fieldnotes, video, and evidence of student engagement.

Tasks. For each observed lesson, I collected materials related to the task or tasks implemented, whether or not they were part of the written curriculum. These provided data to characterize the nature of the contextual tasks, as I will describe in the data analysis section. This allowed me to address the first research question.

Fieldnotes and video. Answering the first two research questions necessitated appropriate evidence of student engagement and how the teacher set up and implemented tasks. During each lesson, I took detailed fieldnotes, capturing verbal statements made by the teachers and students to the extent possible and nonverbal behaviors indicative of student engagement (such as tone of voice, gestures, taking out materials, and so on). I recorded as much of the classroom activity as possible including the classroom structure (i.e., whole group discussion, small group work, individual work) and times when the class was not working on mathematics (e.g., announcements, dealing with discipline issues, moving desks, cleaning notebooks).

I also took video and audio recordings of each lesson, using table microphones in the center of the focus student groups to capture audio and a video camera fixed on the focus students. The video camera was positioned such that non-participating students were not included in the videos, but it was near enough to the teacher to capture whole-class discussions. Throughout the data collection period, I used the audio and video to expand on my fieldnotes and generate transcripts of lessons.

Engagement protocol. During the observations, I used a protocol that outlined specific student behaviors indicative of cognitive and emotional engagement (Fredericks et al., 2004) to identify events for future analysis and to assign holistic engagement ratings. In real time, I

recorded student discourse as much as possible, focusing on capturing the behaviors in the protocol (see Appendix C for the list of behaviors and ratings used during data collection). The protocol was adapted from a list of behaviors generated from research on cognitive engagement in mathematics classrooms (Brantlinger, 2007; Helme & Clarke, 2001; Nicol & Crespo, 2005). I started with a framework developed by Helme and Clarke (2001) around specific episode types (i.e., whole group, small groups, individuals working in parallel), then consolidated the list when there was overlap to make it easier to reference during observations. For example, I used *student contributes a mathematical idea* to represent “verbalizing thinking,” “exchanging ideas,” and “contributing ideas” from Helme and Clarke’s (2011) list of engagement indicators. I also modified the list based on other research on engagement in mathematics classrooms. For instance, I added the behaviors “student perseveres in the face of challenge” and “student seeks challenge” based on Nicol and Crespo’s (2005) description of student engagement in mathematical tasks.

In my reading, I did not encounter literature providing similar protocols for capturing emotional engagement in mathematics classrooms, possibly because it is difficult to capture students’ emotions through their behavior and it can require a high level of inference (Fredericks & McCloskey, 2012). Based on definitions and descriptions of emotional engagement (Fredericks et al., 2004; Nicol & Crespo, 2005), I added behaviors to the protocol where students explicitly make a statement about their feelings toward the mathematical activity, such as enjoyment and interest. I also included behaviors that indicated excitement and enthusiasm such as encouraging one’s peers, starting in on a task right away, and using animated gestures and tone of voice.

To capture an overall assessment of the students' engagement in real time, I used two holistic scales, one for cognitive and one for emotional engagement. Modeled after the techniques used by Stipek et al. (1998), I assigned a rating for each type of engagement once every five minutes (approximately) during the lesson, or sooner if students shifted from one major activity to another (e.g., when the class transitioned from lecture to small group work). Whereas Stipek et al. (1998) used several 3-point scales, I incorporated general behaviors into two 4-point scales based, again, on literature on engagement in mathematics classrooms (Brantlinger, 2007; Buck et al., 2012; Fredericks et al., 2004; Nicol & Crespo, 2005). I rated cognitive engagement from 1 (disengagement) to 4 (elaborate engagement). The term and concept *elaborate engagement* are drawn from Brantlinger (2007), who defined it as students contributing ideas measuring more than two lines of written text in the transcript. In real time, to code student engagement as a 4, I watched for students providing extended (multiple-sentence) mathematical explanations or ideas. I also rated emotional engagement from 1 (active resistance) to 4 (enthusiasm, excitement, eagerness). See Appendix C for a brief description of each holistic code. I assigned cognitive and emotional engagement ratings based on the general state of the focus students as a group, or the behaviors that most of the focus students or the class as a whole were exhibiting.

I attended to the validity and reliability of the process of taking fieldnotes and transcribing both through the pilot studies and through a second observer who attended class and took fieldnotes during two lessons, one at each site. Our discussions and comparisons of notes and reflections following each lesson led to clarification of engaged behaviors and more thorough descriptions of evidence of engagement. In particular, the second coder noted far more instances where students were *disengaged* while I focused on evidence of engagement, though

our holistic impressions of student engagement were fully aligned. This highlighted the inferential nature of capturing student engagement during classroom observations and the importance of multiple data sources in this study. I also reviewed her notes of non-verbal student engagement to check against my transcripts. She noted the same behaviors I identified in the transcripts (e.g., students raising hands, excited tone of voice indicated by exclamation points, gestures that helped communicate mathematical thinking, students trading papers), although she also noted behaviors that I ultimately did not count toward evidence of engagement, such as taking out books and materials when asked. That is, I may have “undercounted” non-verbal evidence of student engagement because I excluded these examples of what I interpreted to be indicators of behavioral engagement, or being “on task” (Fredericks et al., 2004).

Lesson-Specific Surveys by Teacher and Students

At the end of each observed class period, I administered brief (i.e., two to three minutes) lesson-specific surveys to the teacher and all participating students (see Appendices D and E for sample surveys). These surveys included two Likert-scale questions that asked the participant to rate students’ cognitive and emotional engagement; the student version also asked students to relate the mathematics lesson to a food, sporting event, or movie. The format of the Likert-scale questions mirrored the real-time holistic ratings from the observations. Together with the observation data, the responses to these questions primarily provided information needed to identify the relative levels of student engagement as required to answer the first two research questions. In particular, the self-reports provided by the survey data helped to counter researcher bias introduced by the observation data.

The metaphor questions on the student survey asked students to complete the statement(s), “If today’s math lesson were a (food, sporting event, movie), it would be _____,

because ____”, These questions served a different purpose, as they provided data about the motivational factors underlying student engagement by soliciting students’ reactions to the lesson at a more complex level. They were adapted from a survey instrument used to “reliably assess students’ mathematical dispositions and map the emotional terrain of each classroom regarding students’ assent to being instructed” (Cai & Merlino, 2011, p. 147). The authors based the survey on the notion that metaphors provide a way to express one’s thoughts and feelings regarding complex ideas (Cai & Merlino, 2011). I modified the question to be specific to individual lessons rather than about students’ mathematical dispositions in general. By asking *why* students feel the way they do about the lesson, I was able access some of the reasons behind student engagement (or lack of engagement) across the class.

Focus Group Interviews

Finally, to gain a fuller understanding of students’ experiences from their perspective, I conducted five monthly semi-structured focus group interviews with the six focus students at each site (see Appendix F for the interview questions and an overview of the lessons preceding each interview). Though individual interviews may have allowed each student to say more about a lesson, it was not possible to interview every student after a lesson due to time constraints—I conducted interviews during lunch immediately after class to support students in accurately reflecting on their experiences. Group interviews allowed me to hear from every focus student for specific lessons and thus compare responses across students. The purpose of these interviews was to explore students’ self-perceived level of engagement and the reasons underlying their feelings about tasks in greater depth than allowed by the surveys. Specifically, I explored the links between their choice to engage in the task (or not), their underlying motivation to learn mathematics, and the nature of tasks as evidence to answer the third research subquestion.

During the interviews, I ensured that every student had multiple opportunities to answer each questions and tried to maintain an environment in which students felt comfortable sharing. Each interview took approximately 20 minutes. I took notes during the interviews and audio recorded the group using a table microphone. Each evening following an interview, I used the audio to complete the notes and fully transcribe the interview.

Beliefs and Values Survey

During my second visit to participating classes, I administered a beliefs and values survey (Appendix B) as a secondary data source to gain a baseline measure of students' attitudes toward and motivation to learn mathematics, and to select focus students. Students completed the survey in approximately fifteen minutes. It included mainly Likert-scale questions focused on student beliefs related to expectancy-value theory—namely, how confident students were in their mathematical ability, their beliefs about utility value, their enjoyment of mathematics, and mindset related to learning mathematics. These questions were adapted from two existing instruments: Items #1-11 were adapted from Wigfield & Eccles (2000; available at <http://www.rcgd.isr.umich.edu/msalt>). Information on validity and reliability of the items related to expectancy and value can be found in a report by Eccles, Wigfield, Harold, & Blumenfeld (1993). Items #12-15 were items from Dweck (2007) to assess students' mindsets, which I adapted to make mathematics-specific and to clarify language as needed. I added items 16 and 17 to capture some of students' interests in and out of the classroom, which helped in selecting more diverse groups of focus students. In Table 3, I summarize the data source and how they supported each research question.

Table 3

Map of Research Questions to Data Sources

Research Question	Contributing Data Sources	Description
Question 1	Task as written by teacher or appearing in curriculum	Having the tasks allowed me to characterize the nature of the contextual task in terms of type, centrality, and authenticity of the context.
	Classroom observation – fieldnotes	Scripted fieldnotes provided a record of student behaviors to code for student engagement as well as records of teaching moves. Thus, the notes contributed to the identification of the level of student engagement in each lesson and the characterization of the implementation of the tasks.
	Classroom observation – video	The video data allowed me to fill in missing data in the fieldnotes taken in real time. These transcriptions were used to code teaching moves and student contributions to characterize the enactment of the tasks.
	Classroom observation – coding protocol	In conjunction with the fieldnotes, the protocol was used to code student behaviors and provided the means to record a holistic assessment of student engagement. This data was used to identify the lessons in which students were most and least engaged.
	Student survey	The student survey provided a second measure of student engagement from their own perspective. It provided a validity check on my researcher evaluation of engagement.
	Teacher survey	The teacher survey provided another measure of student engagement from a third perspective. It provided a validity check on my researcher evaluation of engagement.
Question 2	Same as question 1	As with question 1, the observation fieldnotes, video, coding protocol, and lesson-specific surveys contributed to identifying the lessons in which students were most and least engaged and to the characterization of the teacher and student actions that contributed to the enactment of contextual tasks.

Table 3 (cont'd)

Question 3	Student surveys	The open-ended question on the survey (i.e. the question that asks why students chose the metaphor they did) provided data on why students engaged the way they did and their responses to specific tasks for every participating student. These responses also served as a basis for prompts in the student interviews.
	Interviews	The interviews provided opportunities to ask students questions about their engagement (both from their own and my perspectives) and to access their perspective on the lesson and tasks in more detail than allowed by the survey.
	Initial attitude/beliefs survey	A secondary data source, students' responses to the initial survey were used to characterize students' motivation to learn mathematics and checked against students' responses to various tasks in interviews and lesson-specific surveys.

Note on Validity of Measures

Triangulating the data through the use of teacher and student surveys, researcher observations, and interviews helped ensure concurrent validity for the measures of student engagement. Table 3 shows how I used at least three data sources in answering each question. As I describe in the analysis section, I correlated the results of these measures, and based the selection of high- and low-engagement lessons on results from all four measures. Finally, in addition to informal conversations on student engagement and task implementation after each lesson throughout the semester, I conducted member checks with Ms. Pearson and Mrs. Meyer at the end of the data collection period in which they reviewed and provided feedback on my initial results and interpretations of the findings.

Data Analysis

Three phases of data analysis were necessary to answer the first two research questions. In the first phase, I ranked the observed lessons at each school according to the level of the

class's engagement in order to identify the lessons in which students were most and least engaged. In the second phase, I characterized the contexts in the tasks as written and as implemented in the identified lessons, and in the third I identified patterns and commonalities between the contextual tasks and instruction in the lessons with highest and with lowest engagement. Finally, to answer the third research question, I analyzed students' survey and interview responses using expectancy-value theory for theoretical coding. In the following sections, I describe each of these phases of analysis in greater detail.

Ranking Lessons by Engagement

In the first phase of data analysis, I ranked the observed lessons by students' engagement level in order to identify the high- and low-engagement lessons for each class. To do so, I took into account four data sources for each lesson: students' numerical survey responses, teachers' survey responses, the holistic engagement ratings, and counts of evidence of engagement. I chose to generate aggregate scores for cognitive and emotional engagement rather than address each individually. Research on student engagement has used widely varied definitions of engagement incorporating elements of behavioral, cognitive, and emotional engagement (e.g., Arnold, 2010; Brown, 2009; Buck et al., 2012), but this research typically generated single measures of student engagement. For the purposes of this study, both cognitive and emotional engagement played important roles. I considered the level of cognitive effort students put into a task to be valuable alongside student affect relative to the task, particularly in supporting motivation to learn mathematics. That is, students might work on and think hard about a task (exhibit cognitive engagement), but feel discouraged negative toward what they are doing. They could also be happy and energetic in the mathematics classroom (exhibit emotional engagement), say because

the teacher told a joke unrelated to the content. Neither type of engagement alone supports motivation to learn mathematics as well as the two working in tandem.

Students' and teachers' lesson-specific survey numerical responses. To generate a single value representing students' self-reported engagement for each lesson, I added students' numerical responses representing their self-reported cognitive and emotional engagement, then averaged these aggregate scores across each lesson for the six focus students in each class. Similarly, I added the teachers' ratings representing cognitive and emotional engagement for each observed lesson. This yielded single values ranging from 2 to 8 for teachers' and students' reports on student engagement for each of 27 lessons. I eliminated Observation 14 at Southpoint Junior High from the study because the students did not take the survey at the end of the lesson; students were preparing for their final semester assessments that day, which meant they did not work on specific mathematics tasks and did not have time for the survey.

Holistic engagement ratings. I averaged my real-time cognitive and emotional engagement ratings over each lesson to get two ratings between 1 and 4. Then, I added them to yield an aggregate holistic engagement score for each lesson between 2 and 8, parallel to the student and teacher results. I considered weighting the holistic scores by time—that is, determining how many minutes of each lesson focus students were rated at a 1, 2, 3, or 4—to generate a holistic engagement score. I chose to use averages, however, because I aimed to look across each lesson (and not, say, focus on moments of peak engagement) to identify high- and low-engagement lessons. These moments of particularly high or low engagement were accounted for in later analyses of lesson enactment.

Counts of evidence of engagement. Counts of evidence of cognitive and emotional engagement provided another observation-based measure of student engagement. These counts

required coding each lesson transcript for evidence of engagement using the engagement protocol discussed previously (see Appendix C for a list of engaged behaviors). As I coded two initial lessons, one at each site, I expanded the list of engaged behaviors in Appendix C into a lesson engagement codebook (see Appendix G).

When coding a lesson, I considered each contribution and noted non-verbal behavior for the focus students. I used the list of engaged behaviors generated from prior literature on student engagement in the mathematics classroom and iteratively developed and used the codebook to identify evidence of student engagement. Then, I noted the actor(s) in the event; the type of cognitive and/or emotional engagement (e.g., student contributes a mathematical idea, student shows visible excitement through tone of voice); and whether student engagement was related to mathematical content, the context of a task, or both. After coding the lesson, I counted the total number of distinct events showing evidence of student engagement across the focus students. Finally, I recorded the number of distinct events showing evidence of each student's engagement for more in-depth analysis of individual students' engagement. This contributed to findings related to student motivation to learn mathematics as the underlying factors of engagement.

After coding all 28 lessons, I calculated the number of engagement counts *per hour*. I found how many minutes students were working on mathematics content by eliminating the time spent on non-mathematical activity identified during the observations, and scaled the counts of engagement evidence accordingly. This provided more consistent observation data across lessons and sites, since the two classes were different lengths.

Notes on coding. The initial coding raised issues regarding situations when student engagement was ambiguous. One was when students participated in *interaction segments* with other students or the teacher, defined as “student- or teacher-initiated series of turns in an

interaction around a single topic” (Jansen, 2008, p. 77). Within interaction segments, it was sometimes unclear when students showed new evidence of engagement. Interaction segments often included a short series of statements and questions in which the student repeatedly exhibited the same type of engagement, such as completing a peer or teacher utterance or answering a direct question from the teacher. In these cases, I chose to count the interaction segment as a single piece of evidence of cognitive engagement. So, for example, if in an interaction segment the teacher asked a student a question, the student responded with a brief answer, the teacher asked a follow up question, and the student again responded with a brief answer, I identified one count of student engagement. As an example, consider the following interaction segment from Lesson 10 at Southpoint Junior High School.

Ms. Pearson: So if I go five miles in 20 minutes, how many minutes are in an hour?

Emily: Sixty.

Ms. Pearson: So if I go 5 miles in 20 minutes, how many 20 minutes are in 60 minutes?

Emily: Three.

Ms. Pearson: Three, so if there are three “20 minutes” in 60 minutes, that ratio would be equivalent to what I would have to do to the 5.

Emily: To get 20?

In this interaction segment, Emily provides brief answers to Ms. Pearson’s direct questions around a single topic. Using the guideline I described, I counted this as one count of cognitive engagement. If students had a pattern of extended responses or showed different types of engagement in an interaction segment, multiple counts were possible.

When coding for student engagement within an interaction segment was unclear, particularly when students exhibited multiple types of engagement in an interaction segment, I considered the following questions: Is this student engaged *in this moment*? How do I know? Did

the student just prepare a single answer to a teacher's question or a single question to ask? Or, do they *persist* in engaging? Do they ask a relevant follow-up question or continue explaining an idea further, worthy of another count of engagement evidence? This helped to clarify whether one or more examples of student engagement existed in the segment.

A second scenario where student engagement was ambiguous was when students made a comment related to the context but not necessarily the mathematical content of the task. In some of these cases, I coded students' contributions as self-monitoring or reflective self-questioning if it seemed they were checking or making sense of their solution. For instance, in Lesson 14 at Pine River Middle School, Drayton found his solution and exclaimed, "a 25-foot shadow? [...] That's like, bigger than this room!" In this and other cases where a student contributed to a discussion about the context and it was closely linked to the mathematics in the task, I counted evidence of cognitive engagement. Other comments on the context were peripheral or seemingly random and did not count as engagement at all. In other situations, students' comments indicated they were excited about the task (at least the storyline of the task), indicating emotional engagement. For example, in Lesson 8 at Southpoint, Kim said to her small group, "Wow, that's a lot of calories! Look how much calories that is." Kim's statement did not necessarily show evidence of cognitive engagement in the mathematical content, but did show evidence of excitement or surprise (i.e., emotional engagement) related to the context of the problem.

A third scenario requiring clarification was when students raised their hands in a lesson. Unless a student was called on, it was sometimes unclear why the student was raising their hand or what they were thinking in the moment (e.g., maybe they were going to ask to use the restroom or sharpen their pencil.) Thus, I only coded these instances as evidence of engagement when students raised their hand *in response to the teacher posing a question*, making it clearer

they intended to share a mathematics idea, complete a teacher utterance, and so on. Without knowing the nature of students' potential responses, I counted hand-raising as emotional engagement because the gesture indicated some level of confidence or enthusiasm in participation. When multiple focus students raised their hand, I noted each as showing emotional engagement, but only gave the event one count of evidence of engagement. I clarified and made coding decisions on these issues and several others through the initial coding, and included them as notes in the lesson engagement codebook.

Reliability coding. A second coder double-coded two lessons for a check on reliability. I selected the lessons because my research memos and holistic engagement scores suggested they had high and complex levels of student cognitive engagement, providing opportunities for discussions about multiple coding issues. The second coder was a colleague at another university with experience in secondary mathematics classroom observation and video coding. First, she coded the transcript for Pine River Lesson 9 using the lesson engagement codebook. I compared our two sets of codes for how we identified the actors, type of engagement, and counts for each interaction segment. Then, we considered each other's codes without discussing them and resolved several issues where there were initially disagreements by referring back to the guidelines in the codebook. Finally, we discussed the remaining events and resolved our coding to full agreement. We iteratively revised the codebook through this process, focusing on the points identified in the last section.

Next, we coded the transcript for Southpoint Lesson 9 using the revised lesson engagement codebook. We reached full agreement by discussing individual events. An example of a point we needed to clarify was regarding evidence of negative affect—for example, a student saying, “I don't like this!” or “I don't care!” Since the focus of the study was on

engagement that supports motivation to learn, we collaboratively decided to only include indications of positive emotion as emotional engagement. Using the final, revised codebook, I went back to the first lessons I had coded to revise prior codes that changed as a result of checking inter-rater reliability.

Comparing engagement results by data source. After analyzing the data for student engagement, results from four different measures were available to support identification of the most and least engaging lessons—teacher and student average ratings, average holistic ratings, and counts of evidence of cognitive and emotional engagement. This was the first step in answering the first two research questions on the relationships between student engagement and specific characteristics of mathematics tasks related to context. To consider the relationship between the four measures, I first found Pearson Correlation Coefficients for each pair of data over the lessons at each site. The correlation matrices for each class are included in Tables 4 and 5. I found that most correlations between ratings of engagement were moderately (0.4-0.7) or highly (> 0.7) correlated. Generally, the correlations were higher between focus students, the teacher, and myself at Pine River than Southpoint. The counts of evidence of engagement, however, had weak or no relationship between the focus student responses. This was an unanticipated result, because the engagement counts were based on specific observable behaviors across lessons and underwent inter-rater reliability coding, and thus were in some ways the most rigorous and objective measure.

Table 4

Correlation Matrix for Pine River Engagement Results

Measure	Focus student average response	Teacher response	Researcher holistic score average	Researcher counts
Student average response	1	0.523	0.756	0.255
Teacher response	0.523	1	0.707	0.499
Researcher holistic average	0.756	0.707	1	0.568
Researcher counts	0.255	0.499	0.568	1

Table 5

Correlation Matrix for Southpoint Results

Measure	Focus student average response	Teacher response	Researcher holistic score average	Researcher counts
Student average response	1	0.480	0.422	-0.005
Teacher response	0.480	1	0.402	0.451
Researcher holistic average	0.422	0.402	1	0.435
Researcher counts	-0.005	0.451	0.435	1

For a better perspective on these results allowing the identification of most and least engaging lessons, I generated dot plots for each of the four measures, and pairwise scatterplots for each pair of bivariate data (see Appendices H and I). I considered the variation in each measure and looked for outliers that indicated individual lessons that stood out for some reason. The dot plots show visually that the student and holistic ratings were within a small range (2.5 points for average student ratings and 2 points for average holistic ratings), whereas the counts of evidence of engagement showed greater variation with several high outliers (roughly, above 80 for Southpoint and above 100 for Pine River). This suggests that perhaps the variation in student responses was too low for a strong association with the engagement counts.

Another possible explanation is that the different measures were sensitive to different aspects of lesson and classroom structure. That is, students may have more (or fewer) opportunities to participate in the kinds of engaged behaviors captured in the transcripts in certain tasks or lessons, which would be captured in the counts but may not be something students attended to when reflecting on their own level of engagement. For example, at Pine River the engagement counts were moderately correlated with the number of minutes the students spent in small groups ($r = 0.545$). That is, student engagement was higher when they spent more time working as a group of six students than in a whole-class setting. In small groups, individual students generally have more opportunities to share mathematical ideas, explain their reasoning, and pose questions that in a whole-class setting. Students, or at least some students,

may be more likely to take up those opportunities in smaller groups. The counts did not distinguish between small-group and whole-group participation.

This is consistent with existing research on students' motivation beliefs about classroom participation, which suggests some students, particularly those who associate whole-class participation with high risk, prefer to discuss mathematics in small groups (Jansen, 2006, 2008). Students communicated similar beliefs during focus group interviews in the current study. Following Pine River Lesson 5, Lilly and Sophia both stated they felt they were particularly engaged, especially during the small group work. When asked about their favorite part of the lesson, Lilly responded, "the working parts [in small groups]. I don't like discussing stuff with a bunch of people. But when you don't understand something in the small group, you can just ask them." Later in the interview, Sophia stated, "I hate being wrong. I feel embarrassed in front of the whole class." Although these findings do not necessarily mean students in this study were more engaged overall than in small groups than in other classroom structures, the prevalence of particular behaviors captured by the observation protocol seems to be associated with students' work structure.

Other factors outside the amount of small group work time may also have influenced the alignment of student responses and engagement counts. The correlation between time in small groups and engagement counts was lower at Southpoint ($r = 0.241$), possibly because the small group structure was different (recall 2-3 students worked together during small group work at Southpoint, versus the entire focus group at Pine River). In both classes, however, some specific lessons in which the counts disagreed with average student ratings of their own engagement had atypical characteristics. For instance, Lesson 9 at Southpoint resulted in the greatest number of counts of student engagement per hour (144.71) across the 14 lessons, but students did not report

high engagement in the lesson. In the lesson, Ms. Pearson introduced the chip model for making sense of integer operations. There was little small group work in the lesson, and it was interspersed with whole-class work as students worked through problems briefly in groups of three then presented the results to the class. It was the only lesson observed with this format, and although there were many opportunities for student participation (captured in the counts of engagement), there was also “downtime” when a majority of students were not involved in the whole-class discussion (which students might have attended to in their response).

Lesson 6 at Pine River had opposite results—the students reported a high level of engagement, though the counts of engagement were the lowest for any lesson (65.08). Again, it was an unusual lesson in that students were organized into small groups but were primarily working individually in parallel on a graphing assignment. Students indicated in their surveys that they put effort into and enjoyed the task, but as outside observers, Mrs. Meyer and I did not capture as much evidence of engagement.

These examples and analyses suggest that the counts of evidence of student engagement may be more sensitive to activity structure and expectations for student work on specific tasks than my holistic ratings and teacher and student ratings for a lesson. In sum, the counts may be a better predictor of the other measures of student engagement across lessons more similar in task type and lesson structure than I observed in this study. Taken together, the generally moderate association between the students’, teachers, and observers’ measures of student engagement across the 14 lessons in each class indicate that we may attend to different aspects of students’ behavior (and in the case of students, their own thoughts and experiences) when assessing levels of engagement. This highlights the likelihood that observer-centered ratings of student engagement are a limited measure and the importance of drawing on multiple data sources.

Identifying lessons with high and low engagement. Due to the lack of strong correlation between the different measures of student engagement and the importance of accounting for multiple perspectives on student engagement in the study, I chose not to use any single measure to rank lessons in terms of student engagement. Rather, to classify the top and bottom lessons in terms of student engagement, I first identified the five highest and lowest-rated lessons for each of the four measures⁴. Reflecting my commitment to and valuing of students' self-perceptions of their engagement, I next considered the high- and low-engagement lessons as reported by *students* of these 10 lessons and identified any lessons where at least two other measures (between the counts, holistic rating averages, and teacher ratings) “agreed” in terms of the highest and lowest rated lessons. I identified any lessons that met the criterion of being one of students' top or bottom five lessons and being in this category for two other data sources—I did not further prioritize data sources. This strategy resulted in three high- and three low-engagement lessons in each class. Three was a coincidental and not a predetermined number, but provided consistency for the following analyses.

Thus, the results presented in subsequent chapters are based on the students', teachers, and my own perceptions of student engagement, privileging students' reports. Identifying most and least engaging lessons in this way afforded a level of confidence moving forward with characterizing tasks and identifying patterns that multiple sources agreed the noteworthy lessons were or were not engaging for students. This approach was also consistent with literature emphasizing the use of multiple data sources when capturing and measuring student engagement in classrooms. I continue to explore in greater depth the lessons in which the students, teacher, and I disagreed on students' relative level of engagement in Chapter 6.

⁴ With the exception of Ms. Pearson's ratings for the Southpoint class for whom I identified the top four lessons, because after the top four lessons the next three were “tied” at a rating of 6.

Characterizing Lessons

Characterizing contexts as written. In the second phase of data analysis, I characterized tasks as written in each of the lessons identified as high or low engagement to address the first research question. For each task, I considered the content it addressed—the mathematical topic, the learning objectives, the placement of the task in the unit, and whether the task was a contextual task. For contextual tasks, I looked at three aspects of the context. First, I identified the *type* of context, considering several binaries: personalized versus nonpersonalized, community-based versus general, future (adult)-oriented versus student-oriented, imaginative/whimsical versus realistic, and addressing social justice issues or not. Different types of contexts are described with examples in Table 6. It was possible for tasks to be identified as more than one type. For example, many social justice tasks are community-based, and some tasks, like the Wumps task discussed later, have elements that are realistic and others that are imaginative.

Table 6

Different Types of Context

Type	Description	Example
Personalized	Contains some element—name of student, local landmark, school name—specific to an individual student or students in the class	Joe [a student in class] is buying gum at Quick Stop [local convenience store]...
Future (adult)-oriented	Incorporates an idea or activity relevant to adult life, especially career-oriented tasks or personal finance tasks	Martha and Bill are considering different mortgage options...
Student-oriented	Incorporates an idea or activity relevant to the life of a teen, such as pop culture or applying to colleges	Alex borrowed her mom’s car and needs to fill the tank before she brings it home. She only has \$7.50...

Table 6 (cont'd)

Imaginative	Describes an “impossible” situation with some level of whimsy	Calculating areas of land on Mars given a fixed perimeter (CMP, Lappan et al., 2006, 2014)
Community-based	Addresses some situation relevant to the local community	The number of family-owned farms in [local town] has decreased in the last ten years. The table below shows the number of farms operating each year...
Social justice	Tasks emerging from students’ lived experiences and interests that help “students develop sociopolitical consciousness, a sense of agency, and positive social and cultural identities” (Gutstein, 2003, p. 40)	Using mathematics to investigate displacement of people of color through gentrification

The second aspect of contexts I considered was the *centrality* of the context in the task. Different tasks require different levels of attention to the context and to the mathematics. In some tasks, the context is a cover story and the problem can be mathematized easily; in others, the context plays an integral role and must be considered throughout the solution process in order for students to be successful on the task. To capture this in the tasks as written, I determined if the context was: (a) peripheral—the context was unnecessary in making sense of and solving the task; (b) helpful but not necessary in making sense of the task; or (c) necessary in making sense of the task (Wernet, 2011).

Third, I considered the level of *authenticity* of each contextual task defined by Palm (2006) as “the concordance between mathematical school tasks and situations in the real world beyond the mathematics classroom” (p. 43). His framework was intended to describe aspects of real-life situations that are important to consider when simulating these situations. The following

is a partial list of aspects of authentic tasks that were relevant to this study and a brief description of each:

- *Event*: The scenario described in the task has occurred or is likely to occur.
- *Question*: The question posed in the task is likely to be posed during the real-life event.
- *Information/data*: Values provided are realistic, the amount of information provided reflects what would actually be available
- *Solution strategies*: The availability and plausibility of strategies for solving a contextual task reflects strategies available and plausible in the situation being simulated
- *Solution requirements*: There is a close alignment between the mathematics required for completing a school task and the mathematics required to do the task outside of school, as well as the level of accuracy required in the two situations and the types of assumptions allowed
- *Purpose*: The purpose of solving the task and the purpose of solving the associated real-world problem are clear to students.

In determining authenticity, I first “scored” the tasks on a three-point scale for each of the six aspects—a score of 2 indicated full alignment between task and real-life scenario, a 1 meant partial alignment, and 0 meant no alignment. Then, I took into account the scores for each of these aspects of the authenticity framework together, and make an overall judgment of the authenticity of the task (low, partial, full). If the task scored mostly 0s with some 1s, it had low authenticity as written. If a majority of the scores were 1s, it had partial authenticity, and if it scores mostly 2s with some 1s, it had full authenticity as written.

Characterizing contexts as enacted. To characterize the tasks as enacted, I first coded teacher statements and questions related to the context using the framework I developed previously (Wernet, 2011). I coded for specific types of events in five general categories: *positioning* self and others in the problem scenario, *clarifying* aspects of context, *elaborating* on the context as written, *referencing* context while making sense of task or content, and *making meta-level comments* on contexts (e.g., comments regarding why curriculum writers might have used a certain context, explicit direction on how the problem context should influence the solving strategy). I counted these teaching moves and tracked each move by type. That is, for each lesson, I recorded how many times the teacher made elaborating, referencing, positioning, clarifying, and meta-level statements (or posed questions asking students for these types of responses) either in the whole-group setting or with the small group of focus students. Attending to context in one of these ways required the teacher to do more than read the task as written in the curriculum. Again, when counting these moves I used interaction segments to delineate excerpts in which the teachers attended to context. For example, in the interaction segment between Ms. Pearson and Emily presented earlier, although Ms. Pearson used contextual language several times, I counted one instance of referencing the context. Had she also clarified some aspect of the context, I would have counted two instances (one referencing, one clarifying).

Finally, I identified each instance of student engagement that was related to task contexts. These events were any questions, statements, or exclamations about or using the language of the problem scenario when working on a contextual task. Using open coding, I generated categories for ways students used and talked about task contexts. Together, teachers' instructional moves and students' attention to context contributed to descriptions of how tasks were enacted.

Identifying patterns and commonalities in tasks. Once I characterized contexts and determined the lessons in which students are most and least engaged, I looked across tasks enacted in these lessons to identify patterns and commonalities. Specifically, I considered: a) the types of contexts that were addressed in the high- and low-engagement lessons; b) the centrality of the contexts; c) the authenticity of the contexts; and d) the instructional moves used to address contexts, and the frequency with which these moves occurred. That is, I described the nature of contextual tasks and their enactment when students exhibited high and low levels of engagement.

I considered a pattern or commonality to be noteworthy when a characteristic of the tasks or their implementation (e.g., tasks contained realistic contexts, or the teacher referenced the context more than four times) appeared in about four of the lessons within a group and did not occur in more than two lessons in the “opposite” group. For example, when teachers attended to contexts more than 20 times in five high-engagement lessons and only one low-engagement lessons, I considered it a relevant finding. I completed this analysis for each of the two classrooms, then looked for patterns across the two classrooms.

Coding Interview and Survey Data

The goal of the third phase of analysis was to provide a richer understanding of *why* students exhibited higher or lower levels of engagement in specific tasks. It allowed me to build on and speak to broader motivational theory. Student engagement and motivation are complex, and the reasons students communicated for choosing whether to engage in a task and to what extent (e.g., feeling tired, being distracted by a personal situation) helped unpack and make sense of their levels of engagement in specific tasks and lessons. I sought to identify motivational factors that serve as the foundation for student engagement relative to their work on contextual

tasks and looked for evidence of how students' experiences with contextual tasks might influence their motivation-related beliefs about mathematics.

To answer the third research question on motivation factors underlying students' engagement in specific lessons, I considered students' responses to the open-ended question on the lesson-specific surveys across all the lessons in each class, students' contributions in focus group interviews, and any relevant comments by students in the lesson itself. I identified any statement in which students linked their general response to a lesson or their engagement in a lesson to aspects of a task. I used expectancy value theory to code these statements along the central constructs in the theory: ability beliefs, expectancy for success in the task, attainment value (importance), intrinsic value (enjoyment), utility value (usefulness), and cost (Wigfield & Eccles, 2000). For example, to code for students' beliefs about the utility value of a lesson, I attended specifically to students' responses to the interview question, "How beneficial (or useful) do you think the stuff you learned today will be for you, either in this class, future classes, or life outside of school? Why?" When students made statements about their feelings of confidence or competence, or about a task being easy, hard, confusing, and so on, I coded the statements as being related to their expectancy for success or ability beliefs. Comments about a task being fun or boring indicated their level of enjoyment in the lesson.

After considering these statements for individual students, I identified themes in how students responded to contexts relative to students with similar expressed motivation to learn mathematics. That is, I grouped the focus students into low expectancy/low valuing, high/high, and mixed/neutral and looked for multiple students repeating similar attitudes toward lessons. Commonalities among students with similar beliefs about mathematics and themselves as

learners of mathematics supported claims about students' motivation to learn underlying their engagement in contextual tasks.

Limitations and Delimitations of Research Design

As with any study, this investigation required several decisions that bounded and influenced the direction of the study. One such set of choices was around identifying high- and low-engagement lessons. I chose to privilege student perceptions of their own engagement level, while accounting for teacher reports and multiple aspects of my own researcher perceptions. This choice was influenced by calls for research on student engagement and motivation in secondary classrooms that draws on multiple data sources (Fredericks & McCloskey, 2012; Middleton & Spanias, 1999; Turner & Meyer, 2009) and prior research on student engagement and motivation to learn mathematics (Jansen, 2006, 2008; Middleton & Jansen, 2011). Using different or fewer data sources, or emphasizing a different data source, may have yielded different results in terms of the lessons in which students were most or least engaged.

Another choice bounding the study was to use CMP tasks and classrooms. This essentially eliminated the possibility of observing certain types of contextual problems, such as those designed by teachers to draw on students' funds of knowledge (Aguirre et al., 2012), problems posed by students themselves around their own interests (English, 1997; Lavy & Shriki, 2010; Mason, 2000), or TMSJ tasks (Brantlinger, 2007; Gutstein, 2003, 2007a, 2007b). Yet, the affordances of CMP made the study feasible by providing frequent and regular lessons with a variety of contextual tasks as part of the core curriculum, which would likely not have been possible in a traditional or typical classroom.

Finally, although I coded specific behaviors indicative of cognitive and emotional engagement to help identify evidence of the two types of engagement, I did not differentiate

between them when identifying noteworthy lessons in terms of student engagement. For example, asking a clarification question, offering a brief response to a teacher's direct prompt, and contributing a mathematical idea to a discussion were all examples of cognitive engagement captured in this study (Helme & Clarke, 2001). Grouping these behaviors together as cognitive engagement rather than differentiating between them may have influenced the outcome of the study, as there may be a difference in the cognitive *demand* of these examples of engagement. Attending to and analyzing specific types of evidence of engagement may offer a more detailed picture of the relationship between contextual tasks and student engagement in future research, but ultimately was not necessary in identifying most- and least-engaging lessons and was outside the scope of the study.

CHAPTER 4

STUDENT ENGAGEMENT AND CONTEXTS AS WRITTEN

The purpose of this study was to explore the relationship between contextual tasks and student motivation and engagement in learning mathematics. To gain a better understanding of the nature of contexts and instructional practices that relate to higher (or lower) levels of engagement, I considered the characteristics of contexts and instructional practices during task implementation across 14 lessons in each of two classrooms. The goal of this analysis was to gain a more nuanced perspective on how the type of context in a task as well as its authenticity and centrality relate to student engagement and students' experiences with these problems.

The first research question asked, “What characterizes the contextual tasks as written in lessons during which students show particularly high and low levels of engagement?” The variables of interest in answering this question are the task characteristics and student engagement. Task characteristics include whether or not the context was personalized, adult- or student-oriented, imaginative or realistic, whether or not the context was community-based, and whether the context addressed social justice issues. I also considered the centrality of the context—how necessary it was to attend to the context in making sense of a problem—and the authenticity of the context, or how well the story aligns with a real-life situation. I attended to both cognitive and emotional engagement exhibited by students, that is, evidence of student investment in learning mathematics as well as positive affect as captured in student and teacher surveys and my observations.

In this chapter, I present findings on the lessons for which students reported and/or exhibited the highest and lowest levels of engagement and describe the tasks used in those lessons. I found that students were more likely to show high levels of engagement in contextual

tasks than noncontextual tasks. Their engagement in contextual tasks was also related, however, to the placement and learning goals of the task and the function of the context in problem solving. In high-engagement lessons, the tasks tended toward open-ended modeling tasks with contexts central in solving the problem.

These results suggest that contextualizing mathematics has potential to engage students both cognitively and emotionally, especially in open-ended modeling tasks when students can use the context to support problem solving in a variety of ways. Based on these findings, I argue that contextual tasks engage students by eliciting genuine interest in the context itself, providing entry into and support in solving the problem, and anchoring the instruction to provide students a shared experience on which to develop their understanding of the mathematical concepts.

I unpack these findings by first providing general information about the 28 observed lessons, then identifying the three high- and three low-engagement lessons in Pine River and Southpoint. To provide the reader a clear picture of the tasks given to students, I describe the task as written or as modified by the teacher for each of these noteworthy lessons, focusing on characterizing the contextual scenario(s) in the tasks. Finally, I consider the trends across the lessons in which students exhibited high and low engagement in order to explicate what aspects of contextual tasks might support or hinder students' engagement in mathematics tasks. In the next chapter, I will consider in greater depth the enactment of these tasks by teachers and students.

Description of Observed Lessons and Tasks

Lesson Overview

Table K1 in Appendix K summarizes the content, placement, learning goals, and key aspects of the tasks and their implementation in the 28 lessons observed at Pine River and

Southpoint. Most of the lessons were “typical” in that they followed the Launch-Explore-Summary structure of CMP tasks, and students focused on one core problem in small groups. Any lessons that did not follow this common structure (e.g., the class completed a task from the prior day before starting a new task or the teacher significantly modified a task as written) are described in the last column of Table K1, “Other Notes on Lesson Activities.” The lessons covered a range of mathematical content, including numbers and operations, proportional reasoning, geometry and algebra. They also covered a range of learning goals, from providing an introduction to the ideas in a unit to reviewing concepts before an assessment.

A majority of the lessons observed at both schools involved contextual tasks to some extent; that is, tasks with some realistic or imaginary scenario described using nonmathematical language or images. Five of the lessons did not include any contextual problems, 11 included references to contexts (e.g., money or changes in temperature) that were not part of the main problem presented to students, and in 12 lessons, the main problem was a contextual task. The lessons with core tasks that were non-contextual primarily came from the units on integer operations (*Accentuate the Negative*) and characteristics of polygons (*Shapes and Designs*).

Identification of High- and Low-Engagement Lessons

Of the 28 observed lessons, I identified those at each site in which the focus students reported and/or exhibited the highest and lowest levels of engagement, using the processes discussed in the methods chapter. Table 7 presents the student and teacher reports, holistic ratings, and counts of evidence of engagement for each of the lessons. The high- and low-engagement lessons for each class are also indicated in the table.

Table 7

Lesson Engagement Results

Pine River Middle School					
Lesson	Average Student-Reported Engagement Rating	Teacher-Reported Engagement Rating	Average Holistic Researcher Rating	Weighted Counts of Evidence of Student Engagement	Identified as High- or Low-Engagement
1	6	4	5.06	72.00	Low
2	5.67	6	5	81.00	Low
3	6.8	5	5.3	81.00	
4	7.5	6	5.51	83.00	
5	6.6	5	6	115.00	
6	7.4	5	5.3	65.08	
7	7.33	8	6.3	89.00	
8	7.5	8	6	80.40	High
9	7.6	8	6.36	133.00	High
10	7.5	8	6.09	147.00	High
11	5.2	6	4.8	76.00	Low
12	5.6	6	5.37	127.12	
13	7.3	7	5.73	141.00	
14	6.33	4.5	5.4	87.00	
Southpoint Junior High School					
Lesson	Average Student-Reported Engagement Rating	Teacher-Reported Engagement Rating	Average Holistic Researcher Rating	Weighted Counts of Evidence of Student Engagement	Identified as High- or Low-Engagement
1	5.2	4	5.73	54.44	
2	6	7	5.82	61.09	High
3	5.5	6	5.3	82.91	
4	5.2	7	6.6	70.38	High
5	4.41	5.5	6.1	108.98	
6	5.17	3	5.72	51.76	
7	5.42	8	5.7	123.75	High
8	4.59	6	5.08	40.00	Low
9	4.84	7	6.2	144.71	
10	3.84	5	5	90.55	Low
11	4.8	6	4.9	43.33	
12	4	2	4.95	63.60	Low
13	4.07	5	5.5	63.27	

Note: Recall that counts of evidence observed in each lesson were weighted to be a measure of counts per hour of mathematical activity, because class time lengths were different and time spent on nonmathematical activity was excluded.

As presented in the methods, a relatively low association existed between the student reports and the counts of evidence of student engagement. Recall that in identifying the high- and low-engagement lessons, I started with student reports, and then found agreement between students', teachers', and my measures. Thus, the results presented in the remainder of this

chapter are based on the students', teachers, and my own perceptions of student engagement, but privilege student reports.

Contexts in Highly Engaging Lessons

In the remainder of this chapter, I focus attention on the relationship between various characteristics of contextual tasks, including centrality and authenticity, and student engagement. To begin to address the first research question, I will describe the main tasks as written for each of the six high-engagement lessons identified in the two classrooms. Interestingly, all six of the tasks in these lessons were contextual tasks, though as you will read, the types of contexts and their centrality and authenticity varied. The lessons are organized into two subsections: the first set consists of tasks that posed a contextual question as the primary question for students to answer, and the second includes other contextual tasks. After describing each lesson, I summarize the trends and patterns related to the contextual elements of tasks across the six lessons.

Lessons with Open-Ended Contextual Questions as the Core Activity

Analysis of the tasks in high-engagement lessons revealed that most of the tasks were fairly open-ended contextual tasks. In each case, the teacher focused on one part of the task or phrased their own question for students to answer based primarily on the storyline on the task. On the surface, some questions did not even seem to be particularly mathematical. Students encountered the tasks early in their respective units. I organized these lessons and tasks together to highlight these important characteristics.

Pine River Lesson 8: Solving the mystery of the teacher in disguise. Lesson 8 at Pine River took place mid-semester. The class began a new unit, *Stretching and Shrinking*, and spent the class period working on the opening material for Problem 1.1 (see Figure 2). It is a

contextual task in which the Mystery Club at a middle school is determining the height of a teacher from a photograph so they can figure out the teacher's identity. It is important to note that Mrs. Meyer enacted this task differently than as written in the CMP curriculum, because she used the opening question (the first bullet point in Figure 2) as the core task for the lesson. The actual problem in 1.1 used the same general context, but asked students to enlarge an image from a flyer to use on a poster and then compare angle measures and segment lengths. The task as given to students was more open-ended and allowed students to use the storyline in whatever way they wanted.

As written, the Mystery Club context is non-personalized, general (not community-based), is student-oriented, and is realistic (versus imaginative)⁵. The context is *necessary* in making sense of and solving the task, since the questions students are to answer—how tall is the teacher, and how do you use the picture to estimate the height—are drawn from the Mystery Club storyline. That is, students' solutions to the task answer real-world questions and thus require an interpretation of the contextual features of the task. As for authenticity, the task has *full authenticity as written* because although they may be unlikely, the event and question in the problem scenario are plausible; and the information provided, strategies available to students, and the required accuracy of the solution are aligned with their real-life scenario. Furthermore, both the mathematical purpose of the task (exploring and using mathematical similarity) and the real-life purpose (identifying the mystery teacher) are clear.

⁵ None of the tasks observed clearly addressed social justice issues, as this is not a focus of the CMP curriculum. Thus, although I coded for that feature of contexts and believe it is an important aspect to consider when relating student engagement with types of contexts, I will not include it in my descriptions of the contexts as written.

The Mystery Club at P.I. Middle School meets monthly. Members watch videos, discuss novels, play “whodunit” games, and talk about real-life mysteries. One day, a member announces that the school is having a contest. A teacher in disguise will appear for a few minutes at school each day for a week. Any student can pay \$1 for a guess at the identity of the mystery teacher. The student with the first correct guess wins a prize.

The Mystery Club decides to enter the contest together. Each member brings a camera to school in hopes of getting a picture of the mystery teacher.

One of Daphne’s photos looks like the picture below. Daphne has a copy of the *P.I. Monthly* magazine shown in the picture. The *P.I. Monthly* magazine is 10 inches high. She thinks she can use the magazine and the picture to estimate the teacher’s height.



- What do you think Daphne has in mind? Use the picture and the information about the height of the magazine to estimate the teacher’s height. Explain your reasoning.
- The teacher advisor to the Mystery Club says that the picture is similar to the actual scene. What do you suppose the advisor means by *similar*? Is it different from saying that two students in your class are similar?

Figure 2. Problem statement and image from *Stretching and Shrinking* 1.1

Pine River Lesson 9: Meeting the Wumps and impostors. Lesson 9 at Pine River was the first of two days in which students worked on Problem 2.1 in *Stretching and Shrinking* (see Figure 3). The problems in the investigation have two layered contexts. The first involves a pair of fictional students named Zach and Marta who are designing and programming a computer

game. Specifically, this aspect of the context involves how to animate and change sizes of figures using coordinates. The second context involves video game characters called *Wumps* and determining which characters are Wumps and which are *impostors*.

As written, the contexts in the task are non-personalized and general (not community-based). There are both adult- (designing computer games) and student- (determining who is in the Wumps family) oriented aspects to the context. Similarly, there are both realistic (designing computer games) and whimsical/imaginative (Wumps family and impostors) aspects of the context. The computer design context is *peripheral* to solving task, because once students start calculating coordinates and graphing the figures, they do not need to reference or use that storyline. The Wumps versus impostors context is *helpful but not necessary* in this part of the task. Students could, in theory, ignore the story and focus on coordinates, lengths, and similarity. As for authenticity, the computer programming context has *partial authenticity as written*. Although the scenario is plausible and programmers or game designers do use coordinate points, this kind of work (by hand) would be unnecessary if you were actually programming. You would know ahead of time which figures were similar. The Wumps context is imaginative and thus has *low authenticity as written*.

In this first day of implementing the task, Mrs. Meyer centered students' work around a contextual question—who is similar to Mug Wump is this belongs in the Wump family, and who is an impostor. Students spent most of the lesson graphing the characters. So the lesson started with an extensive exploration of the computer programming context, but it shifted to focus on the Wumps context.

Zack and Marta's computer game involves a family called the Wumps. The members of the Wump family are various sizes, but they all have the same shape. That is, they are *similar*. Mug Wump is the game's main character. By enlarging or reducing Mug, a player can transform him into other Wump family members.

Zack and Marta experiment with enlarging and reducing figures on a coordinate grid. First, Zack draws Mug Wump on graph paper. Then, he labels the key points from A to X and lists the coordinates for each point. Marta writes the rules that will change Mug's size.

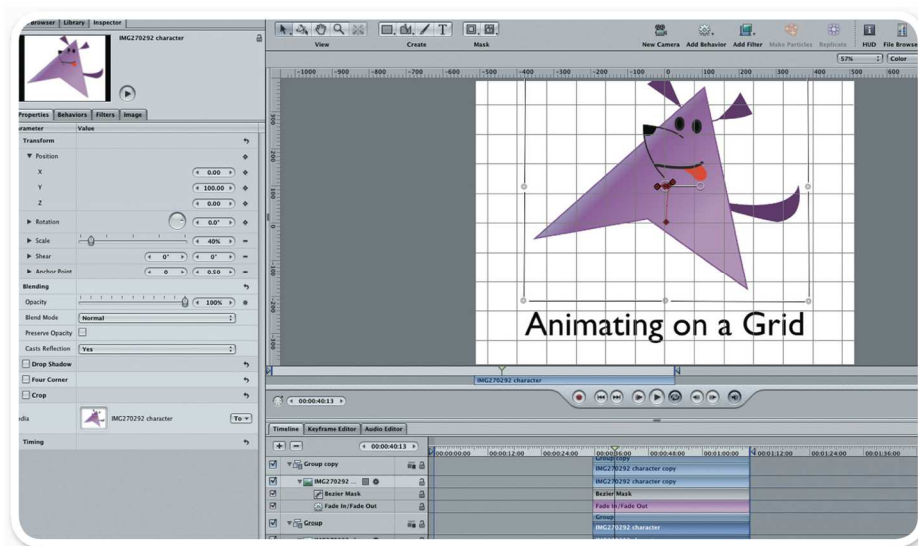
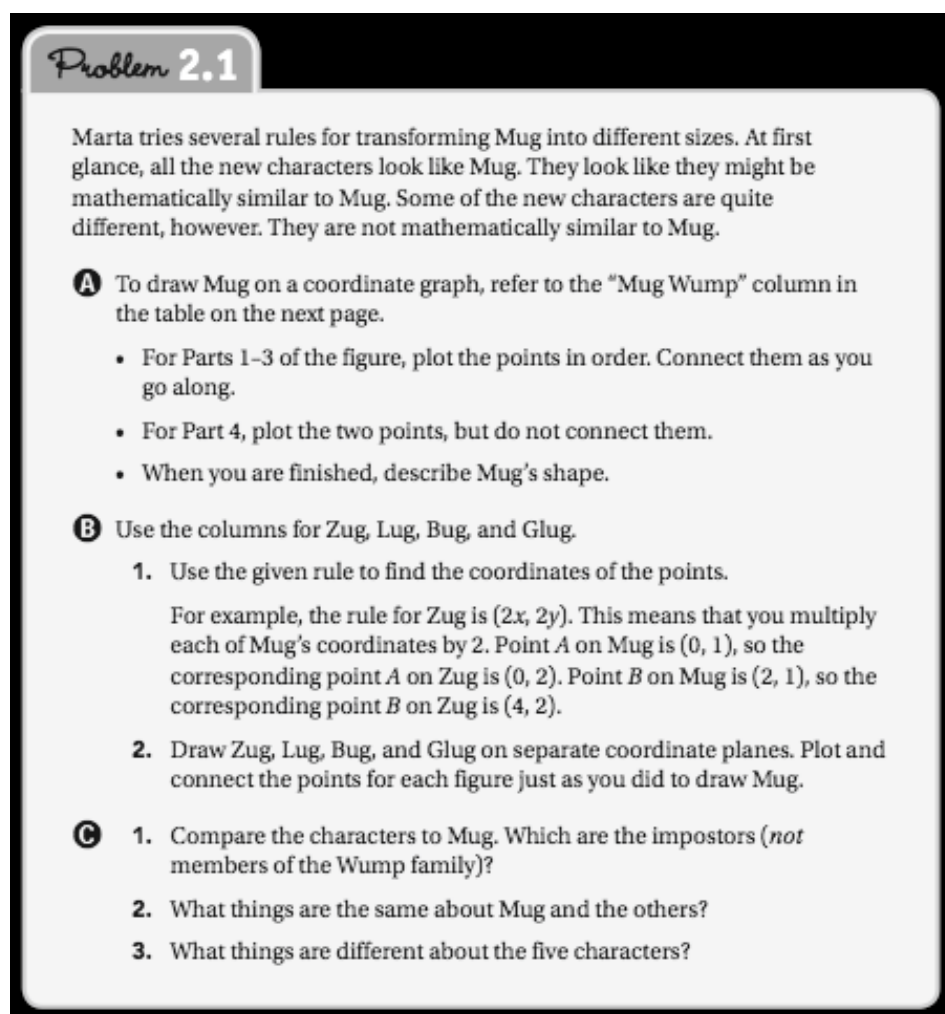


Figure 3. Problem statement and image from *Stretching and Shrinking 2.1*.

Pine River Lesson 10: Mathematizing the Wumps and impostors. This lesson was the second day students spent on the Wumps task. 2.1 As students get into the task as written, though, the actual questions (see Figure 4, problems A-C) do not refer to the computer game design context, but focus on the Wumps versus impostors context. So for this lesson, the context is non-personalized, general (not community-based), student-oriented, and whimsical/imaginative. The Wumps versus impostors context is *necessary* for making sense of this part of the task because whereas the day before students were primarily graphing, in this lesson students focused on the question, “who is similar to Mug Wump is this belongs in the

Wump family, and who is an impostor?” The Wumps context is imaginative and thus considered to have *low authenticity as written*.

The unit of analysis in this study was individual lessons rather than time spent on individual CMP tasks. Thus, it is not particularly surprising that both Lessons 9 and 10 were high-engagement lessons, as they worked on the same task. It is noteworthy, however, that students maintained high engagement for a second day on the task, because it was also likely the novelty would have worn off and students would start to disengage.



Problem 2.1

Marta tries several rules for transforming Mug into different sizes. At first glance, all the new characters look like Mug. They look like they might be mathematically similar to Mug. Some of the new characters are quite different, however. They are not mathematically similar to Mug.

A To draw Mug on a coordinate graph, refer to the “Mug Wump” column in the table on the next page.

- For Parts 1–3 of the figure, plot the points in order. Connect them as you go along.
- For Part 4, plot the two points, but do not connect them.
- When you are finished, describe Mug’s shape.

B Use the columns for Zug, Lug, Bug, and Glug.

1. Use the given rule to find the coordinates of the points.
For example, the rule for Zug is $(2x, 2y)$. This means that you multiply each of Mug’s coordinates by 2. Point *A* on Mug is $(0, 1)$, so the corresponding point *A* on Zug is $(0, 2)$. Point *B* on Mug is $(2, 1)$, so the corresponding point *B* on Zug is $(4, 2)$.
2. Draw Zug, Lug, Bug, and Glug on separate coordinate planes. Plot and connect the points for each figure just as you did to draw Mug.

C

1. Compare the characters to Mug. Which are the impostors (*not* members of the Wump family)?
2. What things are the same about Mug and the others?
3. What things are different about the five characters?

Figure 4. The problem as written in *Stretching and Shrinking* 2.1. Mrs. Meyer focused on one core question: Who are the Wumps, and who are impostors?

Southpoint Lesson 4: Making sense of cola advertising. In this lesson, students worked on the first part of Problem 1.1 in *Comparing and Scaling*. Like the Mystery Teacher problem, this was the first lesson in a new unit and provided an opportunity for students to explore comparison statements in an open-ended task. The lesson opened with a brief introduction to the new goals of the unit before Ms. Pearson launched the task. The context in the problem involved a soda company using the results of a taste test comparing their product with another brand in a new advertisement. Students are given four comparison statements (Figure 5) and directed to make sense of the statements in the first part of the problem. For example, the text asks them to describe each statement in their own words. Ms. Pearson focused on the question, “Which of the above statements do you think would be best in an advertisement for Bolda Cola? Why?” (CMP 2nd edition, *Comparing and Scaling* 1.1).

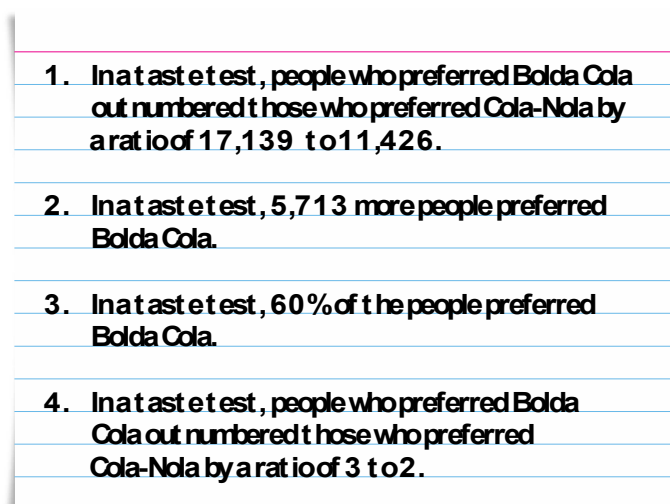
- 
1. In a taste test, people who preferred Bolda Cola outnumbered those who preferred Cola-Nola by a ratio of 17,139 to 11,426.
 2. In a taste test, 5,713 more people preferred Bolda Cola.
 3. In a taste test, 60% of the people preferred Bolda Cola.
 4. In a taste test, people who preferred Bolda Cola outnumbered those who preferred Cola-Nola by a ratio of 3 to 2.

Figure 5. Comparison statements from taste test results for *Comparing and Scaling* 1.1

As written in the CMP text, the Bolda Cola and Cola Nola taste test context is non-personalized, general (not community-based), and realistic. It is both adult- and student-oriented—it is more adult-oriented if analyzing the information from the perspective of an advertiser, but the soda context might be more aimed at students. The storyline does not clearly

address social justice issues, though it could if students focus on being discerning consumers of advertising or the health risks involved in drinking soda heavily. The context is *necessary* in making sense of and solving the task, because every question required students to analyze contextual statements and solve problems related to the two companies and the results of the taste test. The context has *partial authenticity as written* because although conducting taste tests and using results in advertising is common, the specific questions asked of students and available information are not realistic. That is, copywriters would not need to determine some of the specific solutions asked of students.

Other Highly Engaging Contextual Tasks

The tasks in the other two high-engagement lessons did not center around a core contextual question, and both came later in their respective units. They were contextual tasks, however. In both lessons, Ms. Pearson adapted the tasks as written to be group challenges with specified roles.

Southpoint Lesson 2: Exploring similarity in the Wumps' noses and mouths. This lesson took place early in the school year, and as described in the Methods, Ms. Pearson modified *Stretching and Shrinking* 2.3 in CMP (see Appendix A for the written task provided to students) to use in the lesson. Students were organized into small groups of two to three students to complete the task and created a poster to present their work. The modifications to the task were intended to make it more open-ended and emphasize group roles, but maintained the contextual aspect of the task as written in the curriculum.

The task in this lesson continued with the Wumps context. Here, the fictional students Zach and Marta are analyzing pictures of characters' noses and mouths to determine which are those of Wumps and which are those of impostors. The context is non-personalized, general (not

community-based), student-oriented, and whimsical/imaginative. Both the Wumps and computer game design contexts are *peripheral* in making sense of the task. Zach, Marta, and the Wumps are basically a cover story for analyzing shapes for similarity are not necessary to understand for solving a task. The Wumps context is imaginative, and in this task, the context of designing a computer game and not having the information asked for in the task is highly unlikely. Thus, it has *low authenticity as written*.

Southpoint Lesson 7: Analyzing Sascha’s bike trip. As in Southpoint Lesson 2, Ms. Pearson developed a modified version of Comparing and Scaling Problem 3.2 for use in this lesson (see Appendix J for the written task provided to students). The context involves a man named Sascha who is going on a bike trip. There are three legs to the trip. Students were told how long each leg is and how many minutes it took to finish. Then, they were asked to find and compare unit rates and think about how fast they would need to ride to race Sascha.

It is important to note that the problem as written for students represented an instructional choice that was part of the implementation of the lesson, and also influenced how the task was enacted with students. For example, Ms. Pearson changed the word “Stops” to “Legs” and then explained what a leg was in the launch. She also added questions about which legs had the most uphill and downhill portions, which required students to make sense of the biking context in a new way. Finally, in part E about tying in a race, Ms. Pearson wrote an explanation of what a tie would look like mathematically in the problem text, so in that way she clarified an aspect of the context and added to what the textbook had actually asked.

As written in the modified version of the task, the bike trip context was non-personalized, general (not community-based), age-neutral, and realistic. In this task, the context is *necessary* in making sense of and solving the task, because each part of the problem requires analyzing given

information about Sascha's bike trip, making sense of the rates, and tying solutions to units. The problem has *full authenticity as written* because the event—taking a bike trip and recording distances and times for each leg is common and is likely to occur. Moreover, finding average rates and analyzing information on when one rode uphill and downhill is appropriate. The information provided in the problem is reasonable based on Internet searches on typical speeds, and the solution requirements and strategies available to students are appropriate, assuming Sascha did not have access to certain technologies. The mathematical and contextual purposes of the problem are somewhat unclear, though the aspect about racing Sascha (part E) helps clarify one purpose of solving the task.

Trends and Themes in Contexts as Written in Highly Engaging Lessons

The first research question for this study asked what written features characterize contextual tasks in high- and low-engagement lessons. In the previous sections, I described and provided descriptive statistics on the contexts of tasks in each of the six lessons in which students exhibited and reported the highest levels of engagement. Key information and features are summarized in Table 8. In this section, I identify patterns and themes in the six lessons, to be compared and contrasted with low-engagement lessons in subsequent sections.

Table 8

Summary of Features of Tasks in High-Engagement Lessons

Lesson	Contextual Task	Centrality	Authenticity
Pine River 8	Yes	Necessary	Full
Pine River 9	Yes	Peripheral (game design), helpful not necessary (Wumps)	Partial (game design), low (Wumps)
Pine River 10	Yes	Necessary	Low
Southpoint 2	Yes	Peripheral	Low
Southpoint 4	Yes	Necessary	Partial
Southpoint 7	Yes	Necessary	Full

The first notable shared feature of the six lessons is that they all had contextual tasks as the primary learning activity. The contexts of the problems were of the same types—they were location-general (not community-based), non-personalized, and did not address social justice issues. The five tasks included both student- and adult-oriented tasks, but each of the tasks was at least relatable to most middle school students in that students likely have some experience with the various problem scenarios. Contexts such as the Mystery Teacher and the Wumps are stories appropriate for middle school students, whereas contexts such as Sascha’s bike trip and comparing Bolda Cola and Cola Nola are more age-neutral. All of the tasks had some realistic aspect in the context.

The authenticity and centrality of the tasks varied. All tasks except Southpoint Lesson 2 (an extension of the Wumps storyline), however, had partial or full authenticity as written. The Wumps context had low authenticity because it was an imaginative, whimsical context. Further, almost all of the lessons had contextual features that were at least helpful in solving the task, and it was necessary to understand the contextual storyline in four of the six lessons.

Finally, four of the six lessons (three of the five tasks, since Problem 2.1 extended over Pine River Lessons 9 and 10) posed open-ended contextual questions as the *core question* students were expected to answer. In Pine River Lesson 8 students were asked to find the height of the Mystery Teacher, and in Lessons 9 and 10 they were asked which characters in the game were Wumps and which were impostors. In Southpoint Lesson 4, students were asked which of the four statements was most convincing and should be used in an ad for Bolda Cola. Although students needed to mathematize the problems to reach reasonable solutions, the questions themselves were drawn from the problem scenario. Moreover, in the other two tasks—Sascha’s

bike trip and the Wumps' mouths and noses—students were asked several different questions as part of the task, and most of these sub-questions drew on the context in some way.

Contexts in the Least Engaging Lessons

In contrast to the high-engagement lessons, only three lessons in which students reported and exhibited low engagement included contextual tasks. Lessons 1 and 2 at Pine River and Lesson 12 at Southpoint had noncontextual tasks, meaning there were no non-mathematical storylines in any part of the tasks as written or implemented. The two lessons at Pine River came from the unit *Shapes and Designs*; students were analyzing angle properties of polygons. The Southpoint lesson came from Problem 3.3 in *Accentuate the Negative* on dividing integers. Ms. Pearson produced an assignment for this lesson that actually removed the contextual part from the written text that returned to a previous story about a Number Relay. For each of the three low-engagement lessons that included contextual tasks, I will discuss the contexts of the task as written, including the type of context and the centrality and authenticity of the context. Unlike the tasks in high-engagement lessons, these three tasks are distinct in terms of their format and purpose of their contexts. Thus, I discuss them individually before summarizing the trends and patterns related to the contextual elements of tasks across the low-engagement lessons.

Pine River Lesson 11: Counting and Pricing Apples, Bananas, and Eggs

In Lesson 11, Mrs. Meyer piloted an alpha version of a Formative Assessment Lesson⁶ called *Real Life Equations*. The lesson followed a typical lesson structure with an opening launch that reflected back on earlier activities, time for students to explore in small groups (of two or three rather than the usual four to six students), and a whole-class summary discussion. The task

⁶ Formative Assessment Lessons and more information about their development are available at <http://map.mathshell.org>, a project led by Mathematics Assessment Resource Service University of Nottingham and UC Berkeley.

identified the meanings of different variables (see Figure 6), and students were asked to cut out cards with statements and match them with appropriate expressions or equations to make a poster.

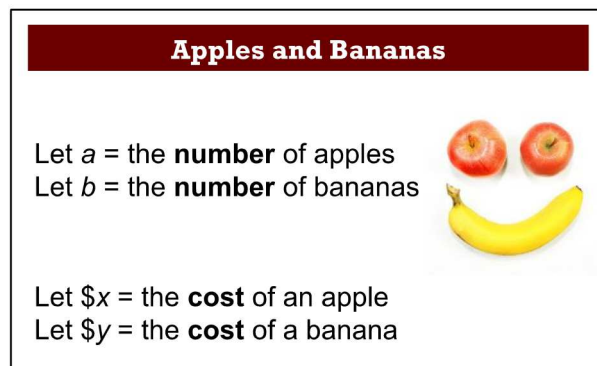


Figure 6. Variables defined in task given to students.

One context embedded in the task involved two fictional students—a boy and a girl whose cartoon images appear in the slides—who disagree about the equations relating two variables. The other contexts in this lesson arose from the everyday referents of the variables. Students interpreted equations and expressions involving the number and price of eggs, apples, and bananas. The task did not have a storyline, other than the single statement, “suppose you are buying apples and bananas in a shop,” which was in the suggested script for teachers and not students’ version of the problem. This food context is non-personalized, general (not community-based), adult-oriented because grocery shopping is often an adult activity, and realistic (versus imaginative).

The context is *necessary* in making sense of the task, because although the objects could have been switched out for anything, the entire task required students to link the meaning of variables with costs and numbers of the objects. Thus, students needed to go back to the context throughout. The context had *low authenticity as written*, because although the “event”—grocery shopping—is part of everyday life, the actual questions posed, strategies students are expected to

use, values given, and mathematical requirements are unrealistic. Shoppers would probably not use expressions or equations in this scenario, making the purpose unclear.

Southpoint Lesson 8: What do Puffins, Airplanes, Enchiladas, and Student Council Elections Have in Common?

In this lesson, students worked on the final task in the unit Comparing and Scaling. The purpose of the task was to synthesize their knowledge about proportions and apply that knowledge to new situations. Thus, this task was different in nature than the other high- and low-engagement lessons. Although students worked on a single problem, each part of the problem used a different context. So the class worked on and/or discussed four different contexts in the lesson: estimating puffin populations (from a homework problem the students went over in class), determining how many miles a jet would take to descend 5280 feet, estimating the number of calories Jack consumed when he ate enchiladas over the course of a year, and comparing a middle school population with the numbers of students on student council by grade.

I analyzed each of the contexts as written separately:

- **Puffins:** The context in the puffins problem is non-personalized, adult-oriented, realistic, and general. It is *necessary* in making sense of task. It has *full authenticity as written* because this kind of tag-and-release technique occurs and is appropriate for estimating animal populations.
- **Jet:** The context in the jet problem is non-personalized, adult-oriented, realistic, and general. The context is *peripheral* because it is easily mathematized without needing to make sense of the jet scenario. It has *partial authenticity as written* because although landing a jet is a reasonable event and the values given are appropriate, one would never use pencil and paper and proportions to determine the landing distance, and it is left unclear why the information is needed.

- **Jack and the enchiladas:** This context is non-personalized, is both adult- and student-oriented, and realistic. The storyline is *helpful but not necessary*, as it is easily mathematized but students need to go back to the context in some parts of the question. It has *partial authenticity as written* because counting calories is a common event and the calorie counts provided are realistic, but the question asked, though plausible, is unlikely.
- **Student council:** The context of determining the number of student representatives for student council is non-personalized, both adult- and student-oriented, realistic. It is *necessary* in making sense of task, because each part requires students to make sense of quantitative relationships related to grades and the number of students. It has *full authenticity as written*; although there are many possible strategies that students do not need to explore and the purpose of solving the real-life problem not be clear to students, it is an authentic situation and one that is likely to occur.

So within this task, the multiple contexts introduced had fairly diverse characteristics, ranging from peripheral to necessary in solving the different parts.

Southpoint Lesson 10: Money Models

Like the last lesson, this lesson was atypical compared with the other observed lessons at Southpoint and Pine River, including both the high- and other low-engagement lessons. The core task of the lesson was a teacher-produced, non-contextual assignment made up of problems drawn from the homework problem set from Accentuate the Negative Investigation 1. The lesson started, however, with an extensive (approximately 38 minutes) discussion reviewing students' work on Problem 1.4, and a few parts involved money contexts. These were stories in which the actors mow lawns, walk dogs, and borrow money from their siblings, or more generally, spend,

earn, and owe money. Also, Emily, a focus student, spontaneously referenced an abstract “point” context in which points were gained and lost.

The money contexts are non-personalized, general (not community-based), student-oriented, and realistic. They are *peripheral* cover stories in which the scenario does not matter, just the numbers and whether the actor is "owing" or "earning," which translates to adding or subtracting positive and negative numbers. The stories have *partial authenticity as written*, because although the events are plausible and likely to occur, and the questions and info are reasonable, the chips and number sentences would not be used in these scenarios and thus there is weak alignment between the purpose of the task and the purpose of figuring out how much money one has.

Trends and Themes in Contexts as Written and Enacted in Least Engaging Lessons

To further address the first research question, in this section I considered the contextual features of tasks as written in low-engagement lessons. Only three of the six lessons in which students exhibited and reported the lowest levels of engagement involved contextual problems in any part. The key information and features of these three tasks are summarized in Table 9. One striking difference between this group of low-engagement lessons and the high-engagement lessons is that whereas the most engaging lessons had contextual tasks as the main mathematical activity, half of the low-engagement lessons did not include any contextual aspects to the mathematics. Three of the five lessons with non-contextual tasks observed across the study period were in this group.

Table 9

Summary of Features of Tasks in Low-Engagement Lessons

Lesson	Contextual Task	Centrality	Authenticity
Pine River 1	No	-	-
Pine River 2	No	-	-
Pine River 11	Yes	Necessary	Low
Southpoint 8	Yes		
	<i>Puffins</i>	Necessary	Full
	<i>Jet</i>	Peripheral	Partial
	<i>Enchiladas</i>	Helpful	Partial
	<i>Student Council</i>	Necessary	Full
Southpoint 10	Core task not contextual; but reviewed contextual homework problems	Peripheral	Partial
Southpoint 12	No	-	-

In some ways, the contexts in the two groups of lessons were similar as written. The contexts of the problems in low-engagement lessons were generally of the same types as those in the high-engagement lessons—they were location-general (not community-based), non-personalized, and did not address social justice issues. The three problems tasks included both student- and adult-oriented tasks, but each of the tasks was at least relatable to most middle school students. Grocery shopping, earning and spending money, and the various contexts in Southpoint Lesson 8 were situations generally familiar to seventh-grade students.

Also, like with the high-engagement lessons, the authenticity and centrality of the tasks varied. There were tasks in which the context was peripheral, helpful-not-necessary, and necessary in making sense of the mathematical concepts. Likewise, there were tasks with low, partial, and full authenticity. Pine River 11, however, was the only lesson observed that had a “realistic” context with low authenticity—the other low authenticity tasks had the imaginative Wumps context.

Though these characteristics of the contextual tasks were similar across the lessons, the three contextual tasks in the low-engagement lessons were different in nature than the high-engagement lessons. All of the high-engagement lessons but Southpoint 2 had core tasks (i.e., students' main mathematical activity) with a single, clear non-mathematical storyline that was central in solving the task. This was not true of the tasks in the low-engagement lessons. Lesson 11 at Pine River had a core contextual task—the entire task involved interpreting variables in expression and equations in terms of their real-life quantities. But the context had low authenticity and did not have any kind of story to clarify the purpose of solving the mathematical or everyday problems. The core task in Southpoint Lesson 8 consisted of three different contextual problems, all of which had more qualities of traditional application problems (i.e., story problems) than the more open-ended tasks in the high-engagement lessons. Finally, the contextual tasks in Southpoint Lesson 10 were not part of the core problem in the lesson, but were from the discussion of the prior day's homework. The class moved on to work on a problem set developed by Ms. Pearson, none of which were contextual as written.

Discussion: Engagement Potential of Contextual Tasks as Written

The first goal of this study was to identify the lessons in which students exhibited high and low engagement and characterize the context, if any, in these lessons' main mathematical tasks. I found that, generally, students showed the most engagement in lessons with contextual tasks, and those contexts were both relatable for students and a central part of problem solving. The low-engagement lessons either did not involve contextual elements, or the problem scenarios lacked the complexity of those in the more engaging lessons. Before considering these tasks as enacted in the next chapter, I unpack these findings on the contexts as written and begin

to frame an argument about the role contexts may play in student engagement in mathematics tasks.

Meaningful Contexts Can Engage Students

The first aspect of tasks I considered in characterizing the contexts as written was the type of context. Though students showed different levels of engagement in contextual tasks, little variation existed in the types of contexts across the observed lessons. This was an expected limitation in choosing to use CMP classrooms in the study, because as a nationally-published curriculum, it does not include personalized or community-based tasks. An important finding, however, is that contexts can be engaging for students. In fact, the data suggests students are more likely to engage cognitively and emotionally in contextual tasks than noncontextual tasks. This finding agrees with literature about meaningful contextual tasks being motivating for students to engage in mathematics (Cordova & Lepper, 1996; Helme & Clarke, 2001; Jansen & Bartell, 2011; Mitchell, 1993; Nicol & Crespo, 2005; Weist, 2001). It also supports the theoretical arguments given by curriculum designers and researchers that contextual tasks are included in curricula in part to promote student engagement and spark their interest in tasks (e.g., Civil, 2002; Gutstein, 2003; Lappan & Phillips, 2009; Nisbet et al., 2007; Romberg & Shafer, 2003; Silva et al., 1990.)

The findings also agree with literature that showed imaginative contexts with low authenticity can be engaging for students, (Nicol & Crespo, 2005; Weist, 2001), as three of the six most engaging lessons involved the Wumps versus impostors context. Yet, all but one lesson with a contextual task (Southpoint 2, Wumps extension) involved some realistic element, whether based on adult or student experiences. Even the Wumps context is prefaced with a real-world context about programming computer games that links the Wumps with the mathematical

content. The important thing to note is that these contexts—imaginative or realistic, aimed at adults or students—were relatable for students. That is, they were *realistic* in the Realistic Mathematics Education (RME) sense of the word.

In Dutch, the verb ‘zich realiseren’ means ‘to imagine’. In other words, the term ‘realistic’ refers more to the intention that students should be offered problem situations that they can imagine...than that it refers to the ‘realness’ or authenticity of problems. However, the latter does not mean that the connection to real life is not important. It only implies that the contexts are not necessarily restricted to real-world situations. The fantasy world of fairy tales and even the formal world of mathematics can be very suitable contexts for problems, as long as they are ‘real’ in the students’ minds. (Van den Heuvel-Panhuizen, 2003)

This description of realistic as “imaginable” emphasizes the need for problem contexts to be personally meaningful for students (Helme & Clarke, 2001; Jansen & Bartell, 2011; Mitchell, 1993; Silva et al., 1990). Moreover, because the tasks in both the high- and low-engagement lessons ranged from low to high authenticity, the results suggest that authenticity as conceptualized in the analytical framework used in this study may not be as important as the extent to which the context is relatable or meaningful for students.

Importance of Task Purpose and Centrality of the Context

Whereas the type of contexts in tasks and their authenticity did not seem to directly influence student engagement, the centrality of the context did appear to be linked to higher levels of engagement. All of the tasks in high-engagement lessons had contexts that were at least helpful in solving the problem except one (Southpoint 2, Wumps extension). Also, as I present in the next chapter, Mrs. Meyer and the Pine River students attended significantly to context when it was necessary for solving the problem even in the low-engagement lesson with the apples and bananas task. This makes sense—regardless of what the context is, if it is necessary to make sense of the context to solve the task, it will likely come up in discussions throughout lesson. It

suggests, though, that the more central the context is in solving the problem, the greater the potential to support student engagement.

This is likely because the problem scenarios can provide entry into and support students' work on the task. As argued by others, (Carraher et al., 1985; Walkington et al, 2012), providing everyday contexts can encourage informal strategies to make sense of the problems, with less opportunity to immediately mathematize the problem. Problems that marry meaningful contexts with contexts necessary to solve the task promote students' appropriate use of the context in solving and may encourages the use of the context to check reasonableness of solutions and strategies. So these two purposes of contextualizing math—supporting learning and engagement—are interrelated, because having access to the task mediates student engagement.

Building on this idea, the relationship between student engagement and task contexts as written seems to be more about the purpose and learning goals of a task and the function of the context in problem solving than the type of context. In the most engaging lessons, task prompts were open-ended and exploratory in nature. They often occurred at or near the beginning of the unit or an Investigation and did not prescribe the mathematical concepts needed to solve. The purpose of these tasks was to introduce new ideas or to give students opportunities to explore, make conjectures, and try to develop strategies for solving a novel problem. In most of these tasks, the context played a central role in making sense of and solving the problem. In these tasks, just the description of the context and accompanying images took up over a page of the textbook! Students could not answer the questions asked without attending to context. In four high-engagement lessons (Wumps, Bolda Cola, Mystery Teacher) the primary questions posed were contextual questions: How tall is the teacher and how do you use the picture to figure it

out? Who are the Wumps, and who are the impostors? Which statement would you use in the Bolda Cola ad?

In the spectrum of contextual tasks, these were closer to *modeling* problems than *application* problems (Ness, Blum, & Galbraith, 2007). Modeling and application are sometimes used interchangeably for any connection between mathematics and the “real world.” But as Ness et al. (2007) describe,

The term "modelling", on the one hand, tends to focus on the direction "reality→mathematics" and, on the other hand and more generally, emphasises the processes involved. Simply put, with modelling we are standing outside mathematics looking in: "Where can I find some mathematics to help me with this problem?" In contrast, the term "application", on the one hand, tends to focus on the opposite direction "mathematics→reality" and, more generally, emphasises the objects involved—in particular those parts of the real world which are (made) accessible to a mathematical treatment and to which corresponding mathematical models already exist. Again simply put, with applications we are standing inside mathematics looking out: "Where can I use this particular piece of mathematical knowledge?" (pp. 10-11).

In most of the high-engagement lessons, the idea was to introduce and support student exploration of mathematical ideas that were new to them, not to apply established mathematical principles to real-world situations. The open-endedness of the tasks gave students opportunities to use the contexts in a variety of ways, as multiple strategies were possible. These results are consistent with motivation literature arguing that opportunities to work on tasks with appropriate levels of challenge and that allow multiple entry points and learning styles promote student motivation and engagement (e.g., Copping, 2012; Engle & Conant, 2002; Middleton & Jansen, 2011; Middleton & Spanias, 1999; Stipek et al., 1998; Suh et al., 2011; Turner & Meyer, 2009). The modeling tasks in the study may promote in students a sense of authority over problem solving more than traditional application problems, and studies have shown this sense of authority is related to student engagement and motivation to learn (Engle & Conant, 2002; Shernoff, 2003; Skinner et al., 2003).

In contrast, task contexts in the low-engagement lessons served different functions. On one hand, they seem to be exceptions to the findings. For example, Southpoint Lesson 8 had contextual tasks in its core activity, and those contexts were fairly central to solving the problems. On the other hand, the function of the context was different than in the high-engagement lessons. The placement of this lesson was at the end of the unit, and thus students were expected to apply what they had already learned to new situations. Though the contexts were still new to them (thus, novelty was not the issue), by that point in the unit students had established procedures for solving such tasks. This was an important point in their learning of the concepts, but the contexts were now something that needed to be mathematized quickly and not necessarily explored. This made the questions more similar to traditional story problems with one primary solution path, which many have argued do not promote student engagement (Boaler, 1993; Chazan, 2000; Gerofsky, 2004; Sullivan et al., 2003; Thomas & Gerofsky, 1997; Verschaffel et al., 2000).

Likewise, students needed to use the apples and bananas context in Pine River Lesson 11 to complete the task. In this case, the difference may have been the type of context. The grocery shopping storyline was more of a *pseudo-context* (Olive et al., 2010) or *microcontext* (CTGV, 1992)—that is, it is a “real-life” and relatable context, but students need to (or can) ignore any complexities in the problem scenario. This creates some risk that students will draw inappropriately on the context, for example, using aspects of the context too literally and letting that stand in the way of mathematizing the problem (Olive et al., 2010; Lubienski, 2000). The openness of the tasks coupled with the centrality of the contexts in the high-engagement lessons allowed students more flexibility in how they used the context to make sense of the problem, helping them avoid these pitfalls. Finally, the highly engaging task in which context was

peripheral (Southpoint 2) was still based on the Wumps context, which had been more central in previous tasks, meaning it was more embedded in the mathematics they were studying in the lesson (i.e., similarity and scale factor).

Summary and Preliminary Argument

In this chapter, I addressed my first research question regarding the relationship between contextual tasks as written and student engagement. In sum, the lessons in which students reported and/or exhibited the highest levels of engagement all included contextual tasks, indicating contextual tasks promote student engagement. Though the level of authenticity and the types of context did not have a strong relationship with the level at which students engaged with tasks, the level of centrality of the context and its function relative to the purpose of the task appeared to be important. The results suggest that contextualizing mathematics can have potential to engage students both cognitively and emotionally, especially in open-ended modeling tasks when students can use the context to support problem solving in a variety of ways.

It is worth considering how contexts supported student engagement in some mathematics tasks. Based on the results presented here, together with those in the next chapter, I argue that contextualizing mathematics plays a role in student engagement in mathematics lessons by: a) catching student interest, b) providing entry into and support in working on mathematical tasks, and c) providing opportunities to anchor the instruction in shared experiences. Here, I simply introduce this argument with a promise to discuss it in more depth after presenting results on the enactment of the high- and low-engagement lessons.

First, the fact that students showed the highest levels of engagement in tasks with meaningful contexts suggests that one reason contexts can promote student engagement in

mathematics is that *students enjoy or like the contexts* themselves. As suggested in the literature, the stories or scenarios can generate students' interest by eliciting an emotional response or relating to something familiar for students (Hidi & Renninger, 2006). Second, all high-engagement lessons had contexts that were at least helpful in solving the task (except Southpoint Lesson 2 with the extension of the Wumps context), suggesting that the more central the context is in solving the problem, the greater the potential to support student engagement. As others have posited (Carraher et al., 1985; Walkington et al., 2012), *contexts can provide entry into and support students' work on mathematics tasks* by encouraging informal strategies to make sense of problems, with less likelihood they will immediately mathematize the scenario. The results of this study indicate that this access to working on the task mediates the relationship between meaningful contexts and student engagement. Third, students' level of engagement seemed to be more closely related to the purpose of the task and the role of the context than the type of context. In the more engaging lessons, tasks were more open-ended and exploratory in nature and the context was a central part of the question students were expected to answer. The tasks were more about modeling than applying established mathematical ideas (Ness, Blum, & Galbraith, 2007). In this way, the problem scenarios served to *anchor the instruction*, allowing students to build understanding of new mathematical concepts on shared prior experiences and knowledge (CTGV, 1992a, 1992b).

So far, I have focused on descriptions of tasks and their contexts as they appear in curriculum materials to highlight the differences in the two sets of high- and low-engagement lessons. In the next chapter, I continue to develop the argument presented here—that contexts can promote student engagement catching student interest, providing entry into and support in working on mathematical tasks, and providing opportunities to anchor the instruction—by

considering the relationship between student engagement and contexts as enacted. Using excerpts from the observed lessons with context-related contributions from teachers and students, I consider in greater depth how attention to problem contexts supported student engagement in these lessons.

CHAPTER 5

STUDENT ENGAGEMENT AND CONTEXTS AS ENACTED

The purpose of this study was to explore the relationship between contextual tasks and student motivation and engagement in learning mathematics. In the last chapter, I presented data on the contexts as written in the lessons where students exhibited or reported high and low levels of engagement. Those results suggested that contextualizing mathematics has potential to engage students both cognitively and emotionally, especially in open-ended modeling tasks when students can use the context to support problem solving in a variety of ways. In the preliminary discussion at the end of that chapter, I introduced the argument that contextual tasks engage students by eliciting genuine interest in the context itself, providing entry into and support in solving the problem, and anchoring the instruction to provide students a shared experience on which to build their understanding of the mathematical concepts.

To further explore and substantiate this argument, in this chapter I present results focused on the enactment of contextual features of tasks in high- and low-engagement lessons, including both teachers' and students' attention to contexts. Specifically, I considered when and how teachers focused students' attention on the contexts and what student engagement related to context looked like in high- and low-engagement lessons. Identifying students' context-related engagement provided another perspective on the roles contexts tasks play in student engagement in mathematics.

I found quantitative and qualitative differences in the way students and teachers attended to contextual features of tasks between the high- and low-engagement lessons. The ways students engaged in contextual tasks appeared to be related to the extent to which their teachers attended to the context during lessons. Students drew on the context more in the high engagement lessons,

and were more likely to connect the context to the main mathematical ideas in the lesson.

Teachers also paid more attention to contexts across the high-engagement lessons, and in more ways (such as elaborating, clarifying, and positioning) than in the low-engagement lessons.

In the following sections, I first describe the frequency and nature of students' context-related engagement, with illustrative examples of student engagement related to the context in high- and low-engagement lessons. Then, I summarize the teachers' attention to the context across the nine lessons with descriptive statistics on the frequency and types of context-related discussion. Finally, I consider the relationship between teachers' and students' attention to task contexts, and present in greater detail two lessons with high student engagement and two lessons with low engagement with representative or noteworthy examples of statements and questions related to the context. The chapter closes with a full discussion of the results on the tasks, instruction, and student engagement related to problem contexts.

Student Engagement Related to Context

When coding evidence of student engagement, I identified each event that was related to task contexts. These events were any questions, statements, or exclamations about or using the language of the problem scenario when working on a contextual task. Through this analysis, I found that the extent to which students attended to the context varied across lessons and across the two classes. There were 266 total instances of students' context-related engagement across the high- and low-engagement lessons. A summary of these counts, including whether the references to contexts were evidence of cognitive or emotional engagement, are provided in Table 10. I will present these descriptive statistics then consider student participation more qualitatively, providing examples of context-related engagement and comparing the nature of this engagement between high- and low-engagement lessons.

Table 10

Summary of Context-Related Engagement by Lesson Phase

Lesson	Context-related engagement	Percent of total	Cognitive engagement	Emotional engagement	Launch	Explore	Summary
High-engagement lessons							
PR 8	26	38.8	24	2	8	13	5
PR 9	62	46.6	30	32	5	55	2
PR 10	75	51.0	32	43	6	61	8
S 2	3	5.4	3	0	0	1	2
S 4	21	34.4	17	4	12	5	4
S 7	34	34.3	32	2	0	29	4
Low-engagement lessons with contextual tasks							
PR 11	29	38.2	23	7	8	17	4
S 8	7	23.3	3	4	0	2	3
S 10	6	7.23	5	2	0	2	0

Note: The context-related evidence of engagement column includes references to prior contexts when reviewing homework or other classroom activities that are not one of the three main phases of the lesson.

What Does Context-Related Engagement Look Like?

Each instance of student engagement related to contexts involved students' verbal participation (including laughter) directly related to the nonmathematical part of a task. Recall that a student raising their hand to offer a contribution to a class discussion in response to a teacher prompt counted as evidence of emotional engagement regardless of whether they were called on, as it showed they were invested in the task enough to voluntarily participate. But these instances were not counted as context-related because there was no way to be sure whether a *potential* contribution was linked to the context or not. So each example is a student statement or question in which they explicitly used language drawn from the context or story in the task.

Using open coding, I identified three ways students used contextual language in the nine high- and low-engagement lessons with contextual tasks:

- **Context only:** Commenting on some aspect of the context or story itself without any mathematical reference;

- **Making sense of and solving tasks:** Using language of the context as written or a spontaneously-generated context while selecting a strategy or making sense of the task requirements, while solving or making sense of the mathematical content, or while checking solutions; and
- **Connecting to learning goals:** Connecting the context to the core mathematical concept or learning goals of the Investigation or lesson.

Each example of students' context-related engagement in the nine lessons fell into one of these three categories. In the following sections, I provide descriptions of each type of context-related engagement, giving specific examples of focus students' statements and questions to illustrate engagement in the categories. I identify speakers by name for a clearer view of interactions in these examples and to show engagement across the focus students—it was not limited to a few students. Table 11 below breaks down counts of student engagement by type.

Commenting on context without connecting to mathematics. Each of the 73 examples of student engagement in this first category was purely context-related. Students talked about some aspect of the story itself without relating it to the mathematical content in that particular moment in the discussion. For example, Jeff, a focus student at Pine River, commented on the name of one of the fictional students solving the teacher mystery during the exploration phase of Lesson 8. He said, “I think it’s kind of ironic that the sleuth’s name is Daphne. You know, like from Scooby-Doo?” Several instances of this type of context-related engagement took place at Pine River during the Wumps lessons. For instance, in Lesson 9, Lilly and McKenna had a conversation about how the Wumps did not have arms, and why they should. In Lesson 10, Lilly asked her group, “Why are we leaving out Bug and Glug? They’re my favorites!” Students commented on contexts in the low-engagement lessons as well, such as when Kim read the

problem in which Jack eats an enchilada every day and remarked, “Wow, that would get boring after awhile...Ah, wow, that's a lot of calories! Look how much calories that is.” These examples, like most others in this category, were examples of emotional engagement because students showed they were excited about or otherwise involved in the problem, but their contribution was not mathematical so they were not necessarily engaged in mathematical thinking at that moment. Some instances where student engagement was purely context related were coded as cognitive engagement, however (9 out of the 73). For example, while discussing the puffin problem during Southpoint Lesson 8, Adelyn asked, “Is that so if one of them died they would know if it was natural causes or a poacher or something?” Although Adelyn was focusing only on the storyline and not solving the problem, she was asking about the purpose of these types of mathematical tasks, and thus it was counted as cognitive engagement.

Using the context to make sense of and solve a problem. Students’ references to the context in this second category, unlike the first, related to the mathematics in the task. A closer analysis revealed that students’ references to the context could serve different purposes while working on a task. First, in some lessons (10 times across the nine high- and low-engagement lessons) students used the context to select a solution strategy or make sense of task requirements. For example, when launching the Mystery Teacher task, Mrs. Meyer asked the students to talk in their groups about how a photograph would help them solve the mystery. Drayton and McKenna offered several ideas, including identifying the teacher by their wrinkles; by looking at whether the teacher was particularly tall, short, or wide; or by finding the brand of shoes the teacher is wearing then asking around at shoe stores. Most of these suggestions were not helpful for solving the problem eventually posed about the height of the teacher, but the problem scenario helped the students begin to think and talk about how to answer the questions

in the task. When beginning the “Real-Life Equations” task in Pine River 11, the class attempted together to interpret an equation. They debated whether the fictional boy or girl’s interpretation was correct, and McKenna asked, “Wouldn’t the boy be right too, because one box equals six eggs?” Here, McKenna aired a misconception, but showed that she was using her prior knowledge about how eggs are packaged to make sense of the equation, which was necessary for solving the upcoming apples and bananas task.

Second, in a few cases students used the context to check and interpret their numerical solutions. In the summary discussion for Pine River Lesson 8, for example, Lilly said she had an answer for how tall the teacher was but did not think it was right. She explained her strategy, and when Mrs. Meyer asked how she knew it was inaccurate, Lilly responded, “Cause I somehow got that she was 7.5 feet tall...that’s really tall.” Going back to the context to make sense of her solution helped Lilly determine her answer was probably incorrect because it was unrealistic.

Third, the students’ referenced contexts while they were solving and communicating about the mathematics. These events included use of appropriate units or other language from the context during problem solving or talking about the mathematical work. It is important to note that students used the context this way most frequently within this category (130 times over the nine lessons), especially in tasks with contexts necessary for solving the task, because it was nearly impossible not to reference the context when talking about those tasks. For example, the following discussion took place while students at Southpoint worked on the Sascha’s bike trip task:

Elijah: So the fastest, which one did he go the fastest?

Lena: Leg 1? Leg 1—he went the fastest in Leg 1? Wait, no. All right, so in Leg 1, for every hour he only goes 15 miles. In Leg 2, Leg 3 [points to her paper]...how do you know if he's going uphill or downhill?

Elijah: [Leaning over the desk to point to Emily's paper] All right, so in one hour he only travels 15 minutes.

Emily: Oh, so Leg 1 would be the slowest.

Elijah: Yeah, and do you go faster or slower when you're going uphill?

Throughout this excerpt, the students use the language of the context (faster, slowest, legs, hours, miles, uphill, downhill) to answer the questions posed and to communicate about the problem and the mathematics. Further, they use prior experience with the scenario—riding bikes up and downhill—to determine which legs of the trip were the slowest and fastest.

Students also made up their own contexts to support their thinking about tasks. For instance, Emily spontaneously created an abstract “points” context to explain her thinking about an integer operation problem in Southpoint Lesson 10. She said, “I just put down -3 minus 5 —okay, I just think about, like—if you have -3 points, and you have to subtract positive 5 —I don't know, I just did it in my head!” It seems she had done the problem but had trouble explaining her thinking, so she tried (though with little success) to generate a context that would help her to think about and justify her work.

Connecting the context with the lesson's core mathematical concepts. The third way students referenced the context was when making sense of or talking about the main mathematical learning goals (see Table K1 for a description of the learning goals for all observed lessons) in the problem or the investigation. Often, this type of engagement took place during the summary phase in the lesson (12 times of the 48 total instances of connecting to core

mathematical concepts). Students' contributions related the context to the mathematics, but more to generalized concepts than solving a particular task as in the previous category. For example, near the end of the Mystery Teacher lesson, Felix stated, "That the scene in the picture is exactly the same as how it would be in real life, just smaller," evidence that he was starting to think about what it means for two figures to be mathematically similar. In the first Wumps lesson, as McKenna tried to identify Wumps and impostors, she shared the following idea: "The y goes up and down. So for Glug, the y -axis—he's tall, and the y -axis is three times, so he's going to be taller, and Lug, he's going to be wider because it's $3x$." She was starting to make sense of how to tell if two figures are similar by thinking about their coordinate rules. In the cola ad lesson, Elijah explained to the class how he interpreted a comparison statement to determine the relationship between the numbers of people who preferred each cola:

Well with the results it's kind of big, it's like 15 percent...you have to compare it with something, *that's kind of what we're doing*. Otherwise it's just a number, if it's 5,713 to 1 that's a huge amount, but comparing it to 11,000 it's okay, not huge. (Emphasis added)

In each of these examples, students were linking the context to the main ideas of the lesson.

There were fewer of these examples across the nine lessons high- and low-engagement lessons, likely because it takes longer for those concepts to develop than within a single lesson. There were, however, references in these lessons to past contexts that suggest those contexts were memorable for students and helped them make connections between ideas. For example, the focus group students at Pine River had a short conversation during the Wumps task that they related to a lesson in *Shapes and Designs* from several weeks earlier in which they had determined the minimum number of facts you could tell someone to draw a unique triangle. Mrs. Meyer had used a context in which the students were trying to text someone directions to draw a triangle and needed to use as few pieces of information as possible.

Jeff: There is such a thing as texting about triangles, but there is no such thing as a Mug Wump video game!

Lilly: Why would you text about triangles?

Jeff: Well you might be texting about triangles from your tree stand but there's no such thing as a Mug Wump video game!

While finishing the task later in the lesson, Jeff exclaimed, “Oh my gosh, I think we should change texting about triangles to mailing triangles and texting about Mug Wumps. Because Mug Wump's so much better!” It seems in this case that the texting storyline supported Jeff in linking the triangle lesson to the texting context of the related task and helped him remember the lesson and its main mathematical ideas (how to give instructions for generating unique triangles).

Comparing Context-Related Engagement in High- and Low-Engagement Lessons

Students’ attention to context varied both in quantity and nature between the high- and low-engagement lessons with contextual tasks. As seen in Tables 10 and 11, there was more evidence of student engagement related to problem contexts in the six high-engagement lessons than the three low-engagement lessons with contextual tasks—on average, 35.1% of the total counts of student engagement in high-engagement lessons were related to problem contexts, compared to 22.9% in low-engagement lessons. This indicates that students were not just more engaged in those six lessons, but also that the contexts played a more central role in the way students make sense of tasks and mathematical ideas. No observable differences existed between the two groups of lessons in terms of when (in which phase of the lesson—launch, explore, or summary) students exhibited this engagement. Across the lessons, most of the context-related engagement occurred during the explore phase, which makes sense because that is when students had the most opportunities to share ideas or ask questions.

Table 11 also shows, however, that the *nature* of students’ attention to context was somewhat different across the two sets of lessons. Most notably, in the high-engagement lessons (with the exception of Southpoint Lesson 2, which only had a peripheral context in one part of the larger task), a significant portion of students’ context-related engagement connected to the main learning goals of the lesson. In the three low-engagement lessons, there were no examples of student engagement that connected to learning goals, though students did talk about the context itself and used it to solve the tasks as needed. That is, although in low-engagement lessons the focus students did engage in tasks to an extent, there was no evidence they were engaging with the central ideas in tandem with contexts.

Table 11

Summary of Students’ Context-Related Engagement by Types

Lesson	Total Evidence of Engagement	Context-related evidence of engagement	Category 1: Context only	Category 2: Connects to mathematics in task	Category 3: Connects to learning goals
High-engagement lessons					
Pine River 8	67	26	3	14	9
Pine River 9	133	62	26	29	7
Pine River 10	147	75	29	28	18
Southpoint 2	56	3	0	3	0
Southpoint 4	61	21	6	13	2
Southpoint 7	99	34 (33)	0	22 (21)	12
Low-engagement lessons with contextual tasks					
Pine River 11	76	29	3	26	0
Southpoint 8	30	7 (5)	5 (4)	2 (1)	0
Southpoint 10	83	6 (2)	1 (0)	5 (2)	0

Note: Numbers in parentheses represent the counts of evidence of student engagement in the core task of the lesson.

Also, students paid relatively high attention to the context in Pine River Lesson 11, the only low-engagement lesson with a single context necessary to solve the core problem of the lesson. Several examples of their context-related engagement, however, were situations in which students challenged the authenticity of the task—a task that was titled “Real-Life Equations.” For

example, when students started working on the task, Lilly asked, “These are real-life equations, but who would ever want to know this?” Her comment indicated her skepticism about the “real-life” aspect of the task, a type of negative attention to the problem scenario that did not occur in the high-engagement lessons, even those without full authenticity (e.g., Wumps, cola advertising).

In sum, students attended more to the contexts in high-engagement lessons than they did in low-engagement lessons with contextual tasks, and were more likely to connect the problem scenarios to the central mathematical concepts in the high-engagement lessons. It is difficult to interpret students’ attention to the problem contexts, however, without considering how teachers did or did not talk about the contexts in these lessons. Thus, I turn next to teachers’ attention to contexts during enactment of contextual tasks in the high- and low-engagement lessons.

Themes in Teachers’ Enactment of Tasks in High- and Low-Engagement Lessons

Because teachers are “active designer[s] of curriculum” (Remillard, 2005, p. 214), I anticipated that Mrs. Meyer and Ms. Pearson would modify tasks in the CMP texts at least in part. As expected, they rarely implemented tasks exactly as written, and that included the contextual features of tasks. The two teachers talked about and focused on the problem scenarios in different ways across the observed lessons. In this section, I present descriptive statistics on the teachers’ implementation of contextual tasks and the relationship between implementation and students’ context-related engagement. I also preview some qualitative differences before presenting specific cases of lesson enactment in the next section.

Attention to Context by Type and Lesson Phase

After identifying interaction segments in which teachers attended to context in the nine contextual high- and low-engagement lessons, I coded each as positioning, elaborating,

clarifying, referencing, or making a meta-level comment about the problem scenario. I counted these events for each lesson, noting the lesson phase in which the events occurred. The results are summarized in Table 12. Also, recall that descriptions of noteworthy aspects of the teachers' implementation of tasks across the 28 lessons in the study can also be found in

Table K1.

Table 12

Summary of Teachers' Attention to Context

Lesson	Total Counts of Teacher Attention to Context	Reference	Clarify	Elaborate	Position	Meta-Level
High-engagement lessons						
Pine River 8	25	13	6	1	3	1
<i>Launch</i>	7	0	6	0	1	0
<i>Explore</i>	1	1	0	0	0	0
<i>Summary</i>	17	13	0	1	2	1
Pine River 9	31	16	4	4	5	2
<i>Launch</i>	23	8	4	4	5	2
<i>Explore</i>	3	3	0	0	0	0
<i>Summary</i>	5	5	0	0	0	0
Pine River 10	38	32	4	2	0	0
<i>Launch</i>	3	3	0	0	0	0
<i>Explore</i>	8	8	0	0	0	0
<i>Summary</i>	27	21	4	2	0	0
Southpoint 2	3	3	0	0	0	0
<i>Launch</i>	0	0	0	0	0	0
<i>Explore</i>	0	0	0	0	0	0
<i>Summary</i>	3	3	0	0	0	0
Southpoint 4	34	17	2	10	5	0
<i>Launch</i>	27	10	2	9	5	0
<i>Explore</i>	1	1	0	0	0	0
<i>Summary</i>	7	6	0	1	0	0
Southpoint 7	23 (17)	18 (12)	4	0	1	0
<i>Launch</i>	2	0	2	0	0	0
<i>Explore</i>	3	3	0	0	0	0
<i>Summary</i>	12	9	2	0	1	0
Low-engagement lessons with contextual tasks						
Pine River 11	23	17	3	2	0	1

Table 12 (cont'd)

<i>Launch</i>	16	13	3	0	0	0
<i>Explore</i>	1	1	0	0	0	0
<i>Summary</i>	6	3	0	2		1
Southpoint 8	18 (9)	(7)	(2)	(0)	(0)	(0)
<i>Launch</i>	0					
<i>Explore</i>	0					
<i>Summary</i>	9	7	2			
Southpoint 10	6 (0)	2 (0)	0	2 (0)	1 (0)	1 (0)
<i>Launch</i>	0					
<i>Explore</i>	0					
<i>Summary</i>	0					

Note: Numbers in parentheses represent the counts of teacher attention to context in the core task of the lesson, including launch, explore, and summary phases. The total number includes references to prior contexts while reviewing homework. All of Ms. Pearson's references to contexts in Lesson 10 took place when reviewing homework.

Mrs. Meyer and Ms. Pearson paid significant attention to task contexts in their respective high-engagement lessons. The exception was Southpoint Lesson 2, but at that point in the unit the Wumps context had already been introduced and explored in previous lessons and likely did not need further explanation. On average, the teachers drew on contextual elements in 22 different interaction segments in the six lessons. These events spanned the lessons; that is, they took place in all three lesson phases—launch, explore, and summary. The low numbers in the explore phase make sense, as I only observed interactions between the teacher and the focus group and the teacher's monitoring during explorations was spread out between groups. Further, in the high-engagement lessons, teachers used at least three types of questions and statements related to the context. All but Southpoint Lesson 2 included referencing and clarifying, and at least one of elaborating and positioning.

Because there were only three low-engagement lessons with contextual tasks (and only two with contextual tasks that were the main lesson activity), it is difficult to identify consistent patterns in their implementation. However, the average number of teaching moves that drew

attention to the context in these three lessons was 16, lower than in the high-engagement lessons. Mrs. Meyer had 23 teaching moves that referenced the context in Lesson 11, because although it was inauthentic and without an actual storyline, the apples and bananas context was central and necessary in completing the task. Still, this number was lower than her level of attention to context in any of the high-engagement lessons. Moreover, in these lessons, there was less diversity in the way Ms. Pearson and Mrs. Meyer attended to the context than in the high-engagement lessons. In Southpoint Lesson 8, for instance, Ms. Pearson only drew on the context in the summary phase, and in Lesson 10, she only talked about contexts when reviewing the homework from the night before.

Relationship Between Teachers' and Students' Enactment

The numbers in Tables 10, 11, and 12 suggest association between the extent to which the teachers and students attended to contextual elements of tasks. There is strong correlation between the total counts of teacher attention to contexts and students' context-related engagement across the main tasks in the nine lessons ($r = 0.819$). The lesson phase in which teachers attend to context may have some relationship with student engagement as well, with the launch and exploration being more closely associated with students' context-related engagement ($r = 0.746$ and 0.779 , respectively) than the summary ($r = 0.595$).

Qualitative Differences in Teachers' Enactment of Contextual Tasks

The teachers' enactment of contextual features of the tasks in high- and low-engagement lessons also differed in other more qualitative ways not captured in the counts in Table 12. More specifically, they tended to pay attention to contexts in high-engagement lessons in ways that highlighted contexts as being relevant, important, or interesting. I noted three interesting features

in teachers' enactment of tasks with high student engagement, which I introduce here then elaborate on in the descriptions of lesson cases that follow.

The first distinction was the teachers' *positioning students' experiences relative to contexts*. For example, Ms. Pearson orchestrated an extensive discussion about ads students had seen that compared two products using numerical information in the launch of Lesson 4 (with the cola ad context). Several students had the opportunity to share personal stories, and Ms. Pearson ended with a warning to be smart consumers. This discussion served to position students relative to the advertising scenario and elaborate on the context as written, and was unlike any whole-class discussion in the low-engagement lessons.

The second theme in lesson implementation of high-engagement lessons was *centralizing the role of contexts by opening up the problem*, meaning teachers made the problem more open-ended, allowing for more solution strategies, than written in the text. In Pine River Lesson 8, Mrs. Meyer implemented the Mystery Teacher task differently than as written in the CMP curriculum. As I mentioned in Chapter 4, she used the opening question as the core task for the lesson, which the authors refer to as a *box question*, an open-ended question that can be used in lieu of the written problem. The actual problem in 1.1 used the same Mystery Club storyline, but asked students to enlarge an image from a flyer to use on a poster and then compare angle measures and segment lengths. So from the planning phase, Mrs. Meyer's choice about enacting the task made the storyline about the Mystery Club and teacher more central to the lesson. As written, a teacher could have passed over the highly contextual opening questions altogether or just asked the questions hypothetically rather than using them as the primary task in the lesson as Mrs. Meyer did. Neither teacher increased the centrality of the context in problem solving to this extent in a low-engagement lesson.

Another difference was in teachers' emotional response to tasks, with Mrs. Meyer and Ms. Pearson *showing more positive affect* in high-engagement lessons. For instance, whereas Mrs. Meyer exhibited a lot of positive emotion related to the context in the Wumps lesson, she became frustrated (showed negative affect) in Lesson 11 when students brought up how unrealistic the context was. I will explore these themes further in the next section by describing the enactment of four lessons in detail.

Cases of Enactment of Contextual Tasks

The purpose of this section is to provide a clear picture of the differences in how teachers and student enacted contextual tasks across lessons. Through four diverse lesson cases—one from each class in each of the low- and high-engagement sets—I illustrate how teachers attended to task contexts, providing examples of different types (e.g., referencing, elaborating, positioning), and how this attention was related to student contributions in the enactment of these tasks. I chose the first Wumps lesson in Pine River because the students showed the highest levels of cognitive and emotional engagement. I chose the Southpoint lesson with Sascha's bike trip because it was a fairly typical task relative to the fourteen observed lessons at the site, and the only high-engagement lesson that took place in the middle of a unit. Because Southpoint Lesson 10 offered little to discuss in terms of enactment of contexts, I chose to describe the other two low-engagement lessons with contextual tasks.

Pine River Lesson 9: "Let Me Tell You, You Will Not Forget the Wumps"

The first noteworthy characteristic of the enactment of this Wumps lesson was an extensive build-up of the two contexts, with Mrs. Meyer using all five types of attention to the context. She opened the lesson by showing the launch video provided by the publisher that accompanies the problem. The video provided images of a computer game design program in

which coordinates are used to design and animate a figure. The voiceover explained the context in more detail. Using the video was an instructional choice that elaborated on and clarified the computer programming context in a different way than setting it up verbally, since it provided a shared experience with a visual representation.

Mrs. Meyer highlighted both contexts in the problem launch, but focused on the computer game design storyline. In addition to using the video, she facilitated a discussion positioning students relative to the context. She started the launch with the following:

Once you have the focus question on your paper, I want you to think about what your favorite game is on your computer, your tablet, app on your phone or your parent's phone. Or a video game, like you have an Xbox or whatever. So you're just thinking about that. I want to know what some of your favorite games are.

Several students, including Drayton and Felix who generally showed low engagement, raised their hands to share their favorite games. After reading the problem from the text, Mrs. Meyer added,

Have you ever thought about that while you're playing those games? Like thought about who was the programmer behind the scenes who put it all together? Can you imagine all the things they have to enter into the computer to get those graphics to move the way you want them to move?

This series of questions positioned students relative to and elaborated on the programming context by emphasizing the human aspect of the game. Mrs. Meyer used these discussions to focus students' attention on the role of coordinates, stretching, and shrinking in computer game programming.

Before students started exploring the task, Mrs. Meyer turned to the Wumps context and linked it to the Zach and Marta storyline. She stated,

[Slyly] We have some impostors here, too. We have some people who *want* to be in the Wump family, but they aren't similar. They are the impostors. So what you're going to be doing today is working with several rules that Marta has put together for Zach and playing with all these rules and coordinate points. And you are going to be finding out

who is actually in the Wump family, or who is similar, and who are the impostors, who are not similar.

Here, Mrs. Meyer highlighted the purpose of the task, elaborated on the context (“some people who want to be in the Wump family”), and also made meta-level statements on the context by giving explicit expectations for how to use the Wumps context to solve the problem. From that point in the lesson, the Wumps context (not the programming context) was central in solving the task. Mrs. Meyer referenced it throughout, asking students during the explore phase who were Wumps or impostors and how they knew, and drawing on the context in the brief summarizing discussion. Rather than stripping away the storyline, Mrs. Meyer continued to use the language of characters, Wumps, and impostors when discussing the rules and shapes.

The second noteworthy feature of this lesson was the extent of students’ context-related engagement. All of the focus students talked about and used the Wumps context during the work on the task. There were 26 instances when the students talked about the context itself, separate from the mathematics. While they plotted points and graphed the characters, they made frequent statements and explanations about the figures, such as, “Oh, he looks cool” (Jeff), “He looks funny!” (Lilly), and “He looks *suspicious!*” (Drayton). There were also 29 instances when focus students used the language of the context to support their work on the task. For instance, Lilly commented, “It [the impostor] has to be Glug, or nobody. Everybody else fits in.” McKenna noted that one character’s eyes were in line with his nose, which allowed her to recognize a mistake in her calculation of the coordinates. Throughout the lesson, the Wumps context was a central part of students’ discussion and work.

The third striking aspect of Mrs. Meyer and her students’ enactment of the Wumps task was strong positive affect related to the context. Mrs. Meyer showed significant positive

emotional engagement in the task herself, specifically related to the Wumps storyline. When introducing the task, she started with,

I have to tell you guys that this is one of my favorite problems. I really actually like the whole book of Stretching and Shrinking to be honest. But this problem is just so much fun! What you will notice is that Zach and Marta's computer program involves a family called the Wumps...and let me tell you, you will not forget the Wumps.

This seemed to set the tone for the rest of the class period. As students started working on the problem, McKenna said she had seen someone wearing a Wumps shirt, and Mrs. Meyer laughed with students about the fact that she owns a Wumps t-shirt and planned to wear it the next day. When a student asked if the figures would be in 3D, Mrs. Meyer responded, “you just wait, they’re going to be pretty fancy.” These statements made it clear that she enjoyed this task, was excited to implement it with the class, and believed the students would also enjoy and remember the context.

The focus students also showed enthusiasm and excitement about the Wumps context. As the examples above show, their talk was consistently positive as they talked about the characters and tried to determine who was a Wump and who was an impostor. There were 32 examples of context-related emotional engagement in the lesson, and all six students showed some level of emotional engagement relative to the context. Their enthusiasm continued into the summary discussion. McKenna was excited to discover (or come up with language for) the relationship between Zug and Mug Wump, exclaiming, Zug looks like, just a, a blown-up Mug. They’re similar!”

In sum, there were several interesting characteristics in the way Mrs. Meyer and her students enacted the Wumps task. Mrs. Meyer spent several minutes of the task launch focused on the computer programming and Wumps contexts. Then, students talked extensively about the Wumps context throughout the lesson as they made sense of the task and the mathematics

involved. They appeared genuinely excited to work on the task, which mirrored the excitement Mrs. Meyer exhibited from the beginning of the launch through the end of the lesson.

Southpoint Lesson 7: Using the Bike Context to Make Sense of Unit Rates

Of all the high-engagement lessons, the bike trip task had the most realistic and adult-oriented context. Unlike Mrs. Meyer's implementation of the Wumps task, in this lesson, most of Ms. Pearson's attention to the context occurred in the summary phase. She primarily referenced the context, and there were no instances of elaborating on or making meta-level comments regarding the context. It is possible that Ms. Pearson thought the biking context was familiar enough for students that it did not need further elaboration, or much attention in general.

Ms. Pearson's discussion of the bike trip context in the launch served to clarify key aspects of the context. For instance, she explained the meaning of the legs of the trip when she said,

So when this says "Leg 1," leg refers to the part of his trip. So on the first part of his trip he rode 5 miles in 20 minutes, then he stopped and wrote that down. Then he went an additional eight miles and rode for another 24 minutes, stopped wrote that down. Then he got on his bike again rode 20 more miles in 40 minutes stopped and wrote that down.

After students started working on the task, Ms. Pearson mainly referenced the context using key language, such as appropriate units. For example, in the summarizing discussion Ms. Pearson stated, "In part B, Leg 1 should have been 15 miles per hour and there were a variety of ways you can get it," and later asked, "Given that information then, when was he going the fastest? Which Leg?" These references focused attention back on the storyline rather than just numerical solutions.

Likewise, students frequently used contextual language to solve and communicate about the mathematics of the problem during the exploration and summary. In particular, throughout their work on the problem students used the appropriate terms and units drawn from the task—

miles, hours, biking, and so on. Again, because the context was so entwined in the questions posed (i.e., the context was central to problem solving) it makes sense that the class would attend more to the context. In this task, all parts but the final graphing question required the use of units of some kind. In fact, the focus students never talked about Sascha's bike trip apart from the mathematical ideas, and it was the lesson with the highest number of instances of students connecting the context to the major idea of the lesson (exploring unit rates). For example, Emily and Elijah engaged in the following discussion early in the exploration:

Emily: Hmm...don't you do like 20 divided by 5? 4. So that's four minutes per mile?

That's fast.

Elijah: I don't know...what'd you get for the first one for miles per hour?

Emily: Four.

Elijah: Four? Miles per hour? That would mean she would be biking fifteen minutes per mile.

Later, in the summary, Ms. Pearson asked, "When was he going uphill?" Adelyn responded, "Leg 1...because it's the slowest and usually when you go up hill you go slower." These examples of the focus students' engagement relative to the context are representative of the ways they talked about and used the context throughout the lesson. They generally did not focus on the biking storyline itself, but rather used it to support their mathematical work.

Pine River Lesson 11: Inauthenticity of Apples and Bananas

The first noteworthy characteristic of this lesson was the relatively high attention to the context by the class, particularly in close relationship to the mathematics. Like the enactment of the bike trip task at Southpoint, in the enactment of the apples and bananas task at Pine River, Mrs. Meyer and the focus students drew frequently on the context throughout the lesson by using

contextual language while solving the task. This makes sense, as the context (the number and prices of apples and bananas, not the grocery shopping storyline) was central in correctly matching expressions and equations with different scenarios. Most of Mrs. Meyer’s attention to the context (17 instances) involved referencing the eggs, apples, and bananas in discussions about the equations and expressions. For example, after a student suggested during the launch that there were six full boxes of eggs, Mrs. Meyer said, “Six [eggs] *per* box. So you’re telling me this number, so let’s try that. If we have three boxes of eggs, how many eggs do we have total?” Or, in the summary, she asked, “Okay, so twice as many apples as bananas. So here, you’re adding them together?” These statements and questions referencing the food items while interpreting equations and expressions are representative of the kind of context references Mrs. Meyer used during the lesson.

The students also used these types of references throughout the lesson, particularly during their work in small groups. Though they reported low engagement, the level of their engagement related to the context nearly matched that in the high-engagement lessons. Nearly all of these instances were connected to the mathematics in the task as they interpreted various statements. Consider the following discussion between Jeff and Lilly as they worked through the problem (it is worth noting that Drayton, who was also in their group of three, did not have any relevant contribution during the work time):

Jeff: Let me see this equation. Total cost in dollars— x is two times y , yup. There are half as many apples as bananas, is that statement correct? [He pauses while thinking, murmuring.] No, half as many—

Lilly and Jeff: Yes!

Lilly: These two go here. Do these two go here, do you think?

Jeff: Drayton, figure out where these two go.

Drayton: No, that's Lilly's job.

Jeff: You need to help, Drayton!

Lilly: He's gluing stuff down. It goes right here, it goes right here!

Jeff: ... Now, $y = 2x$ and $x = 2y$. Half—

Lilly: This would be...they're the same numbers. Here.

Jeff: They are the same number of apples for this one.

Lilly: Is this the same cost, then?

Jeff: Yeah, the same cost. Same number of apples.

Lilly: Ba-na-na!!

Jeff: And bananas. [Pause, the two are working quietly.] I'm pretty sure we're done now!

Lilly: I'm not done writing. There's one more box down here.

Jeff: That's the cost of bananas and apples are the same. Apples and bananas are the same cost.

Lilly: [Writing] Ba-na-nas!!

Here, Jeff and Lilly make several references to apples, bananas, and cost, all contextual features of the task. Twice, Lilly says “banana” in a singsong voice as she writes. Most of the pair’s discussion as they worked drew on the contextual language in this way.

The second noteworthy feature of the enactment of the task was that the context seemed to create a distraction for the students in the class and drew negative attention that I had not observed in the high-engagement lessons. Most of the teacher and students’ attention to the context that was not simply referencing it during problem solving addressed the inauthenticity of

the problem scenario. Recall, for example, that early in the lesson Lilly commented, “These are real-life equations, but who would ever want to know this?” When a student skeptically asked about a girl buying individual eggs, Mrs. Meyer clarified that yes, “she needed two extra, and she could buy those individual.”

Later, as Mrs. Meyer was working through a problem with the whole class, they came to an accurate but unrealistic solution.

Mrs. Meyer: Let's say the apple costs 5 dollars.

Student 1: That's an expensive apple!

Mrs. Meyer: I know it. It must be a honey crisp, those are really expensive.

Student 2: Or it's made of gold. [Students laugh.]

Mrs. Meyer: Yeah!

Drayton: What about a Macintosh one?

Mrs. Meyer: So if the apple is 5 dollars, how much is a banana?

Lilly (and others): Ten!

Student 3: Ten dollars?!

Jeff: That's a lot of money for a banana! [Students laugh.]

Mrs. Meyer: It must be delicious.

Jeff: If it's not delicious I'm suing the company. [Students started to laugh across the class.]

Mrs. Meyer: Guys? Obviously, we're just trying to work with some friendly numbers here.

When a student commented on the five-dollar apple, Mrs. Meyer elaborated on the context by suggesting it was a honey crisp apple. At the end, she made a meta-level comment when she

acknowledged to students that the situation was unrealistic and inauthentic, but emphasized the point was the mathematics. This conversation drew attention away from the mathematical idea Mrs. Meyer was trying to address. She had to pull students back into the task and explain the unrealistic values in the problem. In sum, the class did use the context throughout this lesson, but it was primarily when referencing units while solving and discussing the task. When they talked about the context itself, it was primarily to challenge the authenticity and purpose of the problem.

Southpoint Lesson 8: Lots of Contexts, Little Engagement

Recall that the core task in this lesson had several different contexts, including an airplane in flight, a man named Jack who ate enchiladas every day for a year, and student council elections in a middle school. Regardless of the range of problem scenarios in this low-engagement lesson, Ms. Pearson and the focus students attended minimally to the contexts overall. Ms. Pearson only talked about these contexts nine times during the lesson. Interestingly, all of them took place during the summary phase. She did not clarify or highlight the different problem scenarios in the launch or as she worked with the focus group during the exploration. Of the nine events in the summary, two were clarifying and seven were referencing. The clarification was for the student council context, as some students had a difficult time understanding why there should not be equal numbers of students from each grade. Ms. Pearson explained, “When it says fairly, that doesn't necessarily mean equal. You have more seventh graders in this case so you should have more seventh graders on the 35 person committee.” She continued, saying, “They want the student council to represent the student body. So they want more seventh graders because that makes it fair. Fair doesn't mean even though and I think you're thinking even.... I should have the same number of 6th, 7th, and 8th graders.” These statements

are noteworthy because they are the only instances across the nine lessons in which a teacher addressed student confusion about the problem scenario in the summary, after students should have finished the task. In her references to the context, Ms. Pearson posed questions such as, “So how many miles?, ”How many calories for 240 enchiladas?,” and “In [question] B5 when it says how many calories did he eat per day, what type of number are you finding?” These references drew on the relevant units and other contextual language.

All but one instance of the focus students’ context-related engagement during the main task involved the part of the problem with Jack eating enchiladas at work. These were cases in which the students commented on the context itself during the exploration and summary without necessarily connecting it to the relevant mathematical ideas. Kim and Emily both commented that Jack consumed a lot of calories, and Jacob announced, “You would be fat!” Kim also commented about eating the same thing every day, saying, “wow, that would get boring after awhile.” So although this particular problem scenario (eating enchiladas) seemed to catch their interest, it was not in relationship to the ideas of ratio and proportion they were using, and the contexts in the task did little to support their overall engagement in the mathematics.

Summary, and a Note on Comparisons Across Classrooms

This study was not intended to compare classrooms, but I would like to highlight some differences in the enactment of contextual tasks across the two sites. First, there were lower levels of engagement overall in Southpoint. I am not particularly surprised by the lower count of evidence of student engagement at Southpoint, because the small groups only included two to three students to observe during small group work versus all six focus students contributing to discussions in the small group at Pine River. Further, Ms. Pearson used more whole-group discussion (when individual students have fewer opportunities to contribute) than Mrs. Meyer.

However, the focus students at Southpoint also attended to the context less than the students at Pine River—for instance, their average percent of context-related engagement in the high-engagement lessons was 24.7%, compared with 45.5% at Pine River. Also, they did not exhibit the high levels of emotional engagement as in Pine River (see Table 10), and were less likely to connect the context with core mathematical learning goals (see Table 11). Finally, Ms. Pearson attended to the context less overall than Ms. Meyer.

This suggests that teachers, or possibly the mathematical culture in a school, may play an important role in setting the tone when it comes to attending to the context in classroom discussions and while working on tasks. The idea that teachers might influence the extent and nature of students' context-related engagement is supported by the results presented in this chapter, as I found a strong association between how much the teachers and students talked about the contexts and used them when solving problems. Also, in the individual lessons described above, the nature of student engagement around the contexts often reflected the teacher's attention to the contexts. Specifically, students seemed to follow the teacher's lead in terms of how close they stayed to the context when exploring mathematical ideas and their emotional response to the contexts themselves. I explore these relationships further in the discussion.

Discussion: Multiple Roles of Contexts in Student Engagement

The results in this chapter addressed the second research question regarding characteristics of the enactment of contextual tasks in lessons during which students showed particularly high and low levels of engagement. I found that levels of student engagement in contextual tasks were related to the extent to which their teachers attended to the context during lessons. Students drew on the context more in the high engagement lessons, and were more likely to connect the context to the main mathematical ideas in the lesson. Teachers also paid

more attention to contexts across the high-engagement lessons, and in more ways (elaborating, clarifying, and so on) than in the low-engagement lessons.

The results in Chapter 4 suggested that the contextual features of tasks as written have potential to engage students both cognitively and emotionally. I now add that this potential is heightened when the teacher maintains a focus on the context throughout the lesson in varied ways. In that chapter I also introduced an argument to unpack how contexts can support student engagement: Contextual tasks can engage students by eliciting genuine interest in the context itself, providing entry into and support in solving the problem, and anchoring the instruction to provide students a shared experience on which to build their understanding of the mathematical concepts. Now, I explore this argument further and consider how teachers' instructional practices can enhance these three roles of contexts in promoting student engagement.

Contexts as Likeable and Interesting

The level of attention to context students exhibited in the high-engagement lessons suggests that one reason contexts might promote student engagement in tasks is that students find genuine enjoyment in the contexts themselves. As suggested in interest theory literature (e.g., Hidi & Renninger, 2006; Mitchell, 1993), the stories or scenarios can generate students' interest by providing an element of surprise, personal relevance or familiarity with the situation, or identification with characters. The results on students' context-related engagement support this argument, since students frequently talked about the contexts apart from the mathematics when making sense of and working on tasks. They even took note of the contexts in some of the low-engagement lessons, though as in Pine River Lesson 11, in some cases it was to draw attention to particularly unrealistic aspects of the context (and away from the mathematical discussion). Examples of evidence of emotional engagement related to problem contexts are particularly

salient, since early phases of interest development are characterized by both cognitive focus and positive feelings toward an activity (Hidi & Renninger, 2006).

The results also highlight the influence of teacher affect related to context on students' engagement in tasks. Students' interest in the contexts seemed to be supported in part by the teachers' enthusiasm related to context. This finding agrees with extant research on motivating instructional moves (Stipek et al., 1998; Turner & Meyer, 2009) that found a relationship between the classroom teacher's positive affect and enthusiasm and increased student engagement and motivation to learn mathematics. Likewise, evidence from this study indicates that positive affect is related to increased student engagement, including within individual lessons relative to specific contextual scenarios. In two of the lessons with the highest levels of engagement (the Wumps lessons), Mrs. Meyer showed particularly positive feelings. She commented, for example, that the Wumps lessons are her favorite lessons, that the Wumps would be unforgettable for students, and that she was excited to wear her Wumps t-shirt. In so doing, she exhibited clear and consistent enthusiasm for the lessons, and specifically for the context itself.

Contexts Provide Entry Into and Support in Problem Solving

Across the nine focus lessons, the most frequent form of students' attention to context was connecting the problem scenario to the mathematics in the task as they made sense of and solved the task. As discussed in the last chapter, the extent to which students engaged with the context related to how central the context was in problem solving in both the high- or low-engagement. For example, in the apples and bananas task, the context was central and a large portion of student engagement was related to the context even though their overall engagement

was low. Or in the high-engagement Wumps lesson at Southpoint, the context was peripheral to problem solving and students' attention to the context was low.

Thus, the second way contexts might promote student engagement is by providing entry into and support in solving mathematical problems, especially when the context was central in solving the task. By entry, I mean students have a way to start the problem even if they are unfamiliar with or unsure about the mathematics required. The storyline in the tasks gave students something to talk about as they started thinking about and working on the task. For example, Drayton and Felix, two students who reported low motivation to learn, actively participated in the launch discussion in the first Wumps lesson because they took a personal interest in the context (computer games). Or in the Mystery Teacher lesson, students suggested ideas for identifying the teacher that were mostly unrelated to the mathematics in the task but gave students initial ideas about what to look for in solutions. Consistent with other literature on students' performance on contextual problems (Carraher et al., 1985; Koedinger & Nathan, 2004; Walkington et al., 2012), the storylines of the tasks also supported students' problem solving. This role the context played in student engagement took different forms, including assisting with the selection of solving strategies, providing language for students to use as they discussed their work with others, and offering a way for students to check the reasonableness of their solutions.

As with their affective response to problem contexts, the ways in which teachers enacted the contextual features of tasks was also related to student engagement. Across the nine high- and low-engagement lessons with contextual elements, a strong association existed between the extent of teacher attention to context and the percent of student engagement related to context. This finding suggests that if and how teachers emphasize the contextual elements of a problem

relates to students' engagement and attention to context. It seems teachers helped establish norms for emotional and cognitive engagement when it came to the contexts, modeling the extent to which and how students should attend to the problem scenario when solving and discussing contextual tasks.

Literature on mathematics and motivation argues teachers' instructional practices can influence student engagement and motivation, and that these are malleable student characteristics (Middleton & Spanias, 1999; Middleton & Jansen, 2011; Stipek et al., 1998; Turner & Meyer, 2009). The results of this study on the relationship between teachers' and students' enactment of contextual tasks agree with this argument. Further, the results add to the literature by showing that teaching moves not only influence student motivation and beliefs about mathematics generally, but that attention to context can influence the extent of student engagement in specific tasks and the way students draw on the context in problem solving and mathematical discussions.

Contexts as Anchors for Instruction

Finally, I argue that contexts anchored instruction and student learning for some high-engagement lessons, and that teachers' implementation of contextual tasks can augment this role. The Cognition and Technology Group (CTGV) at Vanderbilt University define *anchored instruction* as the use of lessons with meaningful—realistic and interesting—problem-solving contexts, in which students can use prior knowledge and experiences to understand the problem scenario and build on that knowledge as they gain relevant understanding of new concepts (CTGV, 1992a,b). Anchors can be visual or textual.

The fact that students connected problem scenarios to the core mathematical ideas in high-engagement lessons provides evidence that the contexts helped anchor student understanding of concepts. Studies have shown that anchored instruction can lead to

improvement in students' performance on solving contextual problems, use of problem-solving strategies, ability to transfer knowledge to new situations, and attitudes toward mathematics (Bottge, Rueda, Serlin, Hung, & Kwon, 2007; CTGV, 1992b; Rivet & Krajcik, 2008). For instance, one study found anchored instruction in mathematics promoted student achievement for middle school students, including students with learning disabilities (Bottge et al., 2007). The authors posited that anchors allowed students to “see” problems, and provided multiple elements (text, multimedia, visual representations) that interacted to support students—particularly those with learning disabilities—in solving problems.

The results also suggest that teachers' enactment can enhance the role of contexts in student engagement, allowing them to be anchors for students' understanding of specific content. When Mrs. Meyers and Ms. Pearson attended to contexts in a variety of ways across a lesson, particularly in the launch and summary, they made an explicit effort to create a shared experience for students to draw on as they made sense of the mathematics in the task. Often, they called attention to students' prior everyday experiences. The discussions they led about video games (Pine River Lesson 9) and advertisements (Southpoint Lesson 7) are the best examples of the way they drew on students' prior knowledge and experiences through the contexts to help students make sense of tasks and their respective purposes. Further, some questions posed by the teachers explicitly encouraged students to connect contexts with the main mathematical learning goals in a lesson. For example, by asking Lilly, “why is [Bug] so skinny?,” Mrs. Meyer encouraged Lilly to consider the character's coordinates and the role they played in his size and shape, which related to the lesson's core concept of mathematical similarity.

These findings on the influence of teachers' instructional practices involving contexts on student engagement agree with extant literature. Results of a large-scale study in CMP

classrooms designed to describe the relationship between task set-up and student opportunities to learn mathematics in summarizing whole-class discussion indicated that certain aspects of a task launch might relate to higher quality student engagement in the summary phase (Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013). Two of the aspects of setup the researchers studied were discussion of key contextual features of the task scenario and development of common "taken-as-shared" language to describe contextual features, mathematical ideas and relationships, and other vocabulary. These aspects of focus were hypothesized to help students understand problem scenarios and align with the framework used in this study to code implementation of contexts (Wernet, 2011).

Jackson et al. (2013) posited, "students were more likely to make connections to one another's ideas and to provide conceptual evidence for their reasoning in the whole-class discussion when taken-as-shared understanding of the contextual features of the problem-solving scenario was established in the setup" (p. 677). Because making connections to each other's ideas and justifying their reasoning using mathematical concepts are fine-grained examples of student engagement, their findings suggest that attending to the context leads to more high-quality engagement in the summary. My study adds to this by relating both the teacher's and students' attention to context with cognitive and emotional engagement across entire lessons. Whereas Jackson et al.'s (2013) study did not consider the explore phase of the lesson, my results suggest that higher-quality student engagement in the summary may be the result of higher-quality engagement in the task itself—that is, how students worked on the task during the explore phase may mediate the relationship between attention to contextual features in the setup and student engagement with mathematical concepts in the summarizing whole-class discussion. Further, the results presented in this chapter suggest there may be more to the relationship

between attending to context and student engagement than just making sure everyone understands and/or is familiar with the problem scenario to promote equity of learning experience and opportunities. Discussing and clarifying the contexts may promote emotional engagement as well, and centralize the context to anchor students' work on tasks.

Considering Alternate Explanations and Other Factors Influencing Engagement

There were certainly other forces at play influencing student engagement in the two classrooms, and other possible reasons why students engaged more in some tasks than others. For example, there is an ebb and flow in student engagement over a week and a school year, though patterns in engagement played out differently across the two classrooms. There is also the question of novelty of certain tasks and their implementation, a factor known to promote student engagement (Mitchell & Carbone, 2011). Novelty alone cannot explain student engagement in the lessons observed in this study, however, as certain novel tasks such as the apples and bananas task at Pine River did not promote high levels of student engagement, and all of the high-engagement lessons were quite typical of CMP lessons.

The content students were learning likely played a role. All of the high-engagement lessons at Pine River came from the unit *Stretching and Shrinking*, while none of the high-engagement lessons in either class came from *Accentuate the Negative*. The role content plays in student engagement is likely related to the open-endedness of tasks, another factor that seemed to influence student engagement. The high-engagement lessons tended toward those with tasks that allowed for multiple solution strategies and different possible solutions. Tasks in *Accentuate the Negative*, however, generally had a single correct answer with fewer reasonable strategies. Tasks without a clear-cut solution path allowed students more autonomy and choice, which have been

shown to support student engagement and motivation (Engle & Conant, 2002; Mitchell & Carbone, 2011; Skinner et al., 2008; Turner & Meyer, 2009).

Finally, I acknowledge that one limitation of the study is the descriptive nature of the findings—specifically, I described the characteristics of contexts as written and as enacted by teachers and students in high- and low-engagement lessons. Though the evidence suggests relationships between these factors, I make no claims about causality or directionality. For instance, it is possible that a teacher can emphasize a task’s context, or a context can be central to problem solving and meaningful for students, but still not promote student engagement. It would be necessary to analyze more lessons to further explore these types of claims.

Conclusion

It would be reasonable to ask, *Do we want students to be talking about problem contexts in mathematics class? What value is there in spending class time just talking about the problem scenario? How much does it add to or take away from a focus on the mathematics?* These questions are part of the myriad of decisions teachers make in planning and enacting a lesson. True, in a few cases students’ discussion about aspects of problem contexts temporarily led them off track mathematically. Yet, the relationship between high student engagement, contextual tasks, and teachers’ attention to contexts indicates that talking about contexts can be worthwhile in promoting student effort and enjoyment. The fact that students were cognitively engaged and reported greater effort in the high-engagement lessons with contextual tasks suggests that the contexts, and time spent specifically addressing them, supported students in solving problems and making connections to mathematical ideas. Over time, these positive experiences with mathematics may lead to greater motivation to learn. In the next chapter, I turn to how these motivational factors relate to student engagement relative to problem contexts.

CHAPTER 6

THE RELATIONSHIP BETWEEN MOTIVATION TO LEARN MATHEMATICS AND STUDENTS' RESPONSES TO CONTEXTUAL TASKS

In this chapter, I turn from characterizing contexts as written and enacted in high- and low-engagement lessons and focus on students' experiences with contextual tasks more generally, based on what they reported in class observations, surveys, and interviews about particular lessons and problems. In doing so, I discuss how student motivation to learn as assessed through their initial surveys related to their response to contexts. This addresses the third research question: *How does student motivation to learn mathematics (e.g., valuing content, enjoyment of task, alignment with goals) relate to student engagement relative to the contextual tasks used in class?* This question was driven by the fact that, anecdotally, students avoid traditional story problems, which often come at the end of each homework problem set and are considered to be the hardest problems for students to do (Nathan & Koedinger, 2000a, 200b). Yet, contexts are also believed to promote student engagement by representing everyday scenarios where mathematics is needed or useful (e.g., Mitchell & Carbone, 2011). Further, this question addresses a call to research “how individual student differences... moderate the relationship between task characteristics and engagement” (Fredericks et al., 2004, p. 79).

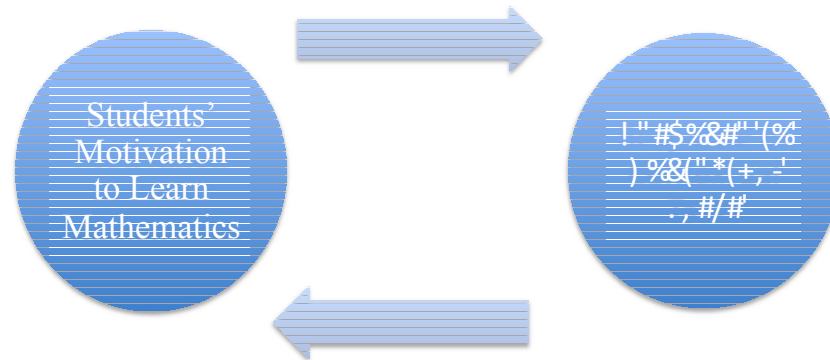
Motivation and engagement—and the relationship between them—are complex constructs. Thus, I pursued operationalized research questions. To explore how students' underlying motivation to learn influences how they respond to contextual contexts, I considered the question, *How do students who reported different degrees of motivation to learn mathematics engage with and talk about problem contexts?*, To consider the other direction of the relationship regarding how engaging with contextual tasks might influence students' motivation-related beliefs, I asked, *Do problem contexts support students beliefs about their success in the task and*

the value of the content? (See Figure 7 for a visual representation of these operationalized questions). To answer these questions, I analyzed students' individual responses to questions on lesson surveys (Appendix D) and interviews (Appendix F) as well as any comments about tasks that students made in class. I coded statements related to their motivation to learn the mathematics using expectancy-value theory, described in Chapter 3 and summarized in the following section. Here, engagement is not based on what the teacher or I observed but on students' reactions to and reflections on lessons and tasks.

I found that the aspects of tasks students attended to (including contexts) when reflecting on the value of mathematical content and their experiences in lessons was related to their underlying motivation to learn mathematics. Trends across groups of students, however, indicate that task contexts play little role in promoting students' valuing of mathematics or beliefs that they can be successful on a task. Based on these findings and those in previous chapters, I argue that contexts in the mathematics tasks studied have potential to engage students in particular lessons or to serve as a cognitive support for students' problem solving, but do not necessarily have the same potential to motivate students to learn. Further, students may respond to contexts differently than intended by curriculum developers and teachers who implement the tasks.

The first part of this chapter presents two major themes in the findings across the whole group of focus students. To illustrate these themes, the second part focuses on three students who represent diverse beliefs in terms of motivation to learn mathematics and what they communicated about their classroom experiences with contextual and noncontextual tasks. I end with a discussion of the findings, highlighting the potential influence of contextual tasks on student motivation and engagement in CMP classrooms.

How do different groups of students describe their experience working on contextual tasks?



Do contextual tasks support students' expectation of success?
Do contextual tasks support students' valuing of the content?

Figure 7. Operationalized questions guiding analysis for research question 3. I conceptualized the relationship between a student's motivation to learn mathematics and their responses to contextual tasks to be bidirectional, with questions to guide each aspect of the relationship.

Theoretical Background

Recall that motivation to learn is the “tendenc[y] to find academic activities meaningful and worthwhile and to try to get the intended learning benefits from them” (Brophy, 2004, p. 16). Motivation more generally is a construct used to explain the reasons underlying one's behavior (Brophy, 2004; Middleton & Jansen, 2011) and is largely non-observable and relatively enduring (Skinner et al., 2008). It is different than engagement, which is observable and can change quickly with changes in, for example, classroom activities. Thus, in this study I focused on engagement as students' reported and observed levels of effort and enjoyment in mathematics lessons. My investigation was guided more broadly by expectancy-value theory, which I describe next along with how I used it to analyze data to address the third research question.

Expectancy-Value Theory

Like other motivation theories, expectancy-value theory explains a person's achievement motivation—or their choice to engage in an activity, their persistence, and their performance—as being a product of their level of expectations of success and the value they place on the reward for success (Brophy, 2004; Wigfield & Eccles, 2000). In this study, the activity of focus is learning through mathematics tasks in 7th-grade classrooms. Thus, I considered students' motivation to learn mathematics—their expectation of success solving tasks and how they valued mathematical knowledge.

The two main constructs in the theory are *expectancy*, or students' beliefs about their ability to successfully complete mathematics tasks, and *value*, or how much they value the knowledge gained through these tasks. These are subjective values, because different people assign different value to the same activity (Wigfield, Tonks, & Klauda, 2009). There are four different aspects of value. The first is attainment value, or the importance of doing well on a task. Attainment value relates to one's identity, as “tasks are important when individuals view them as central to their own sense of themselves, or allow them to express or confirm important aspects of self” (Wigfield et al., 2009, p. 58). The second is intrinsic value, or students' level of enjoyment when working on mathematics tasks. The third is utility value, or students' perception of a task's usefulness and its correspondence with future plans. Finally, cost refers to the level of effort and sacrifice required to be successful.

Taken together, these constructs allowed me to characterize how students reacted to different tasks. Students regularly communicated these motivation-related beliefs through their comments in class and responses to survey and interview prompts. Expressing confidence in their ability to complete a task, enjoyment while working on the task, or belief in the importance

of the embedded mathematics indicated a positive response to the task. Expressing confusion, boredom, a sense that the mathematics was useless, or that the cost of engaging in a task was too high indicated a negative response. Looking across tasks and identifying patterns in how different students responded to contextual and noncontextual tasks allowed me address the research question by relating student motivation to learn and their experiences with task contexts.

Analytical Framework

To explore the relationship between students' motivation to learn mathematics and how they described their experiences working on mathematics tasks (particularly contextual tasks), I considered their responses to the open-ended questions on the lesson-specific surveys across all the lessons in each class, students' contributions in focus group interviews (Table F1 in Appendix F describes the lessons preceding interviews), and comments made while working on mathematics in class. These comments included complete phrases in which students explicitly linked their perceived engagement in a lesson to aspects of the tasks they had worked on in the lesson. Table 13 provides a summary of how I identified students' statements using expectancy-value theory. For the final stages of analysis, I considered patterns in lessons to which each student responded especially positively or negatively, identifying these lessons based on students' lesson-specific self-reports of engagement as well as my observations of their engagement. Thus, from this point when I refer to how students "responded to," "reacted to," or "reflected on" tasks and lessons, I am drawing on students' explicit comments about tasks and their engagement in them.

Table 13

Analytic Framework for Students' Motivation-Related Statements

Expectancy-Value Theory Construct	Nature of Student Comments and Responses
Ability beliefs (focused on current task)	A task being easy, hard, confusing, simple, straightforward, challenging
Expectation of success (focused on upcoming tasks, immediate or long-term)	Feelings of competence or confidence, being challenged, struggling, comments on what kind of math student they are
Intrinsic value (enjoyment)	A task being fun, exciting, boring, a lesson going by quickly
Attainment value	Necessity of learning the content in a task, the importance of doing well for a future math class or to get a good grade
Utility value	The content being useful (or not useful) outside of school, a task's relevance, how closely a task relates to their interests
Cost	Being tired, losing social status, fear of being wrong, rather be doing something else, a task is too much work, stressful

As discussed in Methods, students' motivation to learn mathematics was determined from the initial motivation beliefs surveys administered at the beginning of the study. Felix, Lena, and Emily were in the low motivation group; Drayton, Jacob, Adelyn, Lilly, and Sophia were in the neutral/mixed motivation group because they gave neutral responses to the initial survey questions on motivation beliefs, or had high expectations for success but did not value mathematics or vice versa; and Elijah, Jeff, Kim, and McKenna were in the high motivation group. Again, these groups were determined from early student reports and not what I observed during the study period. The survey results, however, were supported by other evidence as students talked about their perceived mathematics ability, how much they enjoyed mathematics, and so on. Some of the unprompted statements I heard during observations and interviews included:

- Felix telling his peers during class that he goes to math lab, which he described as being “for people who aren’t very good at math.”
- Drayton commenting in an interview, “I feel like I’m not that good of a mathematician.”
- Adelyn commenting, “I usually like math class, though. I used to be good at math class, now I’m just...I didn’t even try, because it was hard.”
- Sophia saying in an interview, “I hate being wrong. I feel embarrassed in front of the whole class.” Later, she said she doesn’t like math, except for some days when she feels smart.
- Elijah remarking to Jacob, “Math is my friend!”
- McKenna commenting, “I kind of like math now, this year it's easier.”

The beliefs students communicated about the usefulness and benefits of learning content in specific lessons also reflected their initial survey results, as presented in the forthcoming results.

The results in this chapter are organized into two parts. In Part 1, I discuss trends across focus group students with diverse motivation to learn. In Part 2, I discuss illustrative cases of three students—Felix, Elijah, and Sophia—who represent different levels of motivation to learn mathematics. Next, I describe the central themes in the data on how students who expressed diverse motivation to learn mathematics responded to different types of tasks.

Results Part 1: Trends in Focus Group Students’ Responses to Tasks

The focus students regularly and openly expressed beliefs about their expectations for success on tasks and the extent to which they valued the content of lessons—both spontaneously while working in class and when prompted in surveys and interviews. My analysis focused on how these responses related to the contexts of tasks and students’ underlying motivation to learn. The findings suggest students’ experiences with certain tasks and their contexts may be more

strongly related to their underlying motivation to learn (whether they are low motivation, high motivation, or somewhere between) than to the nature of the contexts. I identified two main themes in the data. The first related to how students discussed the value of mathematical content in the lesson interviews, and the second related more broadly to what different students attended to when reflecting on tasks.

Contextual Tasks and Beliefs About the Value of Mathematical Content

The first trend in the data addressed the question, “Do contextual tasks support students’ valuing of mathematics content?” as well as how students’ motivation to learn related to what they attended to in contextual tasks. Most of the relevant data came from students’ responses to the interview question, “How beneficial (or useful) do you think the stuff you learned today will be *for you*, either in this class, future classes, or life outside of school? Why?” This question elicited students’ beliefs about the attainment and utility value of mathematical concepts explored in tasks (refer to Table 13 to review these constructs).

Overall, the focus students consistently described potential applications for the content they learned in lessons. Their responses and beliefs about the value of the material, however, differed between motivation groups. Low motivation students were less likely to express a belief that the mathematics they studied was useful and tied possible applications to problem contexts, whereas high motivation students considered broader mathematical goals. Students’ responses to money-related contexts were noteworthy, as these contexts seemed to particularly support students’ beliefs that rational number operations are valuable concepts in their everyday lives.

Generating ideas for future use of mathematical concepts and skills. Across all 28 lessons I observed, neither Ms. Pearson nor Mrs. Meyer explicitly emphasized the usefulness of mathematics content students were learning in the lesson (e.g., saying something like, “you need

to know these concepts for/if you...”). Yet, the focus groups expressed beliefs that the material they learned was valuable in each interview. That is, though not all students may have agreed, whenever I asked, more than one student in each group stated that what they learned would be beneficial or useful. For example, they responded with statements such as, “This is useful in other math classes” (Lilly, Lesson 7) and “Everybody's going to have to know this” (Elijah, Lesson 10). Comments of this nature communicated a belief in the general attainment or utility value of the content they were learning. In these examples, the content was similarity and integer operations, respectively.

Students also identified specific applications for the content or situations in which the mathematical ideas would be useful. When asked if similar figures would be beneficial or useful to him, for example, Jeff responded, “Packaging. If you get a job in packaging you need to know area and perimeter of the product so you can package it” (Jeff, Lesson 10). In two different interviews, Jacob suggested that the mathematics in their lesson would be helpful to physicists (Lesson 7) and accountants (Lesson 13).

Students’ ability to generate these types of examples and the likelihood that they would find the mathematics beneficial did not, however, seem related to whether the lesson contained contextual tasks. As shown in Table 14, students expressed beliefs in the attainment and utility value of the content they learned for both contextual and noncontextual tasks. This implies that engaging in contextual tasks did not necessarily support students in identifying how the mathematics could be useful in future careers or everyday situations, and working on problems without a storyline did not necessarily hinder them from seeing the value of the content or generating applications.

For instance, almost all focus students at Southpoint responded positively regarding the value of learning about scale factor following a lesson in which the Wumps context was highly peripheral to the task (Lesson 2) and discussed its application in carpentry (Kim). Likewise, the focus students at Pine River communicated they believed that multiplying positive and negative integers would be useful and beneficial following a lesson in which no contextual tasks were used (Lesson 7), and identified applications such as banking (Jeff) and business (McKenna). Following Lesson 14, which had a highly contextual task, most of the students at Pine River said they did not think that using similarity to estimate unknown heights would be beneficial or useful in everyday life. Thus, the students did not necessarily perceive more or better applications for mathematics through contextual tasks than through noncontextual tasks.

Table 14

Belief in the Value of Mathematics Expressed in Focus Group Interviews

Lesson	Description of Context	Number of students expressing belief that content was useful/beneficial, neutral, or <i>not</i> useful/beneficial	Applications generated by students
Pine River 2	None	3,0,1	Carpeting, packaging
Pine River 5	Money contexts	2,2,1	Drafting
Pine River 7	None	3,0,1	Working at McDonalds (dealing with money), banking, business
Pine River 10	Identifying Wumps and impostors	3,0,1	Working at McDonalds, designing apps, packaging
Pine River 14	Using shadows to find heights	2,3,1	Architecture, sports, telling time
Southpoint 2	Analyzing Wumps' noses and mouths	2,1,3	Construction, carpentry
Southpoint 5	Determine which cookie mix is the most "chocolatey"	3,1,0	Sales, cooking

Table 14 (cont'd)

Southpoint 7	Sascha's bike trip	3,1,0	Physics, pilot, music producer, general scaling problems in everyday life, biking
Southpoint 10	Money contexts	5,0,1	Student loans, taxes, general personal finance
Southpoint 13	Temperature context	4,1,0	Taxes, jobs, accounting, parenting (paying for kids' expenses)

Note: A neutral response was one where students thought the mathematics would be useful but only for certain professions, would be useful in school but not in real life, and so on.

Motivation to learn and value-related responses to contexts. Though students' value-related responses to tasks did not seem related to whether the tasks were contextual, they did relate to students' motivation to learn mathematics. Students' beliefs regarding the value of the mathematics content explored during the lessons and the applications students generated differed across motivation groups.

Low motivation group. Because they expressed low valuing of mathematics in the initial beliefs survey, it was not particularly surprising the students in this group were least likely to see the material they were learning as useful when asked in interviews. Drayton (neutral on expectation of success, low on valuing mathematics) never expressed a belief in the value of specific topics. He openly challenged the relevance of some contexts, asking, for instance, "when will you need number lines outside of school?" (Lesson 5) and "what about if the sun's not out when you need the height of an object?" (Lesson 14). Similarly, Emily said that the usefulness of mathematics "depends on what you want to do. Like if you want to be a hairstylist you wouldn't use it" (Lesson 2) and remarked about integer operations, "I think we'd all forget about this when we're adults" (Lesson 10).

When students in this low motivation group did talk about the value of the mathematics they were learning outside of school, it was either very general (e.g., "I think it could be useful,"

Lena, Lesson 10) or closely tied to context *when it was a contextual task*. For instance, following Lesson 14 in which students found heights of tall objects using similar triangles, Felix said the topic was, “not really that useful, except in architecture. Tearing down a building, putting it up, measuring how high it is before you tear it down.” Similarly, after the lesson on using ratios to determine which cookies were the most “chocolatey,” Lena said, “I guess if you’re cooking and stuff it would help” (Lesson 10). This phenomenon is noteworthy because it indicates that, for some students, contexts may actually narrow their perception of the value of mathematics and promote the belief that it is only useful in the situations presented in their books.

Neutral and mixed motivation group. Most students in the neutral/mixed motivation group expressed that what they learned was somewhat valuable and recognized the importance of what they were learning, but generally only for future mathematics courses or for other people. That is, they discussed the attainment value and utility value of the content, but for situations they did not consider personally relevant. For example, Jacob explained that different topics they learned would be helpful if one is in certain professions such as being a physicist or accountant, but these were careers he is not interested in. He told me, “I’m not going to be an accountant” (Lesson 13). Lilly gave similar responses. In talking about integer operations, for instance, she said, “Yeah, my dad does math a lot. He works at Meijer warehouse...It will be useful in school, but for what I want to be [an author] I don't think it's going to be very useful. I want to write fantasy books, not math books”.

Often, students in this group took a literal view of contexts. Following the lesson on finding heights of tall objects using similar triangles formed by shadows, Lilly commented that the concept is, “not very useful...it might be useful tomorrow and next week, but not outside of school. What if it's in the middle of winter?” (Lesson 14). Adelyn’s responses were mixed. Early

in the school year, she challenged the practical value of a concept, saying, “I don't think this is ever going to come up when I stranger walks up to you and says, ‘find the scale factor’!” (Lesson 2). For the lesson on rates, however, she described, “It depends on what you want to be, like it would be good if you want to be a pilot or a music producer. I would say very beneficial!” (Lesson 7). Generally, this group of students saw more value in their lessons, but not necessarily for themselves personally.

High motivation group. The high motivation students consistently communicated the usefulness of the mathematical content they learned, and in more specific and meaningful ways than students in the other groups. They often identified specific careers where the skills would be used, or certain kinds of everyday problems one could solve using the ideas. The examples these students generated were not tied to applications immediately related to problem contexts; rather, they related more to the core concepts and objectives of the lesson. Elijah, for example, discussed how comparing ratios in the chocolatey cookies “would be really helpful if you were like a sales rep, because you would need to know stuff about unit rates, and you'd have to be able to make things appealing to the audience. So they'd buy your product, and use all the information.” At different points in the interviews, Jeff talked about how the topics they were learning were relevant to packaging, drafting, and using the sun for telling time—none of which were contexts used in the problems they encountered. For example, after the lesson on similar figures he said, “If you get a job in packaging you need to know area and perimeter of the product so you can package it” (Lesson 10). McKenna generally thought that the mathematical concepts were useful to support learning future topics in school, but also expressed its relevance to her own future. She explained, for example, “I would use [multiplying and dividing integers] at my job, because I want to own a business... I don't know, what jobs *don't* use numbers?” In

sum, the students in the high motivation group attended to broader mathematical goals of tasks when describing the value of a task and did not consider only applications connected to the immediate contexts they explored in the text.

Money-related contexts and rational number operations. The money-related contexts from the unit *Accentuate the Negative* were a special case in that students were able to generate ideas for future use of rational number operations regardless of level of motivation to learn. These contexts supported students across groups in valuing the content in the unit. Most students repeatedly communicated beliefs about the attainment and utility value of rational number operations both because certain professionals use the skills and concepts and because they will need them for personal finance.

Examples of students' responses when asked about the benefits and usefulness of the material, all from three different *Accentuate the Negative* lessons, include:

“I guess it could be useful for adding college debt and student loans and stuff” (Jacob).

“Yeah [it is beneficial], like taxes and stuff...If you were using this to do taxes then you would *not* forget. You would have to relearn it” (Adelyn).

“Probably, yeah, yeah, very [useful]. Taxes...When you're a mother or father, and you have to pay for your kids' stuff” (Kim).

“Banking...banking! You have negative and positive numbers and you have to multiply them” (Jeff).

“I said [this lesson was like eating] carrots, because they don't taste the best but I know they'll be good for me” (Emily).

Though money contexts were used in multiple lessons in the study, these specific examples students offered—determining debt, paying taxes, and banking—were not explicitly referenced

in the lessons I observed. This indicates students bring to bear some personal experience as they interpret task contexts.

Student Responses to Tasks—Expectation of Success and Intrinsic Value

The results in the last section indicated students can think and talk about applications for mathematics encountered through contextual and noncontextual tasks when asked about the value of the content they learned. The second trend in the data, though, was that the students across motivation groups focused almost entirely on the level of ease or challenge they faced (expectation of success) or enjoyment (intrinsic value) in their responses to lessons. Students in different motivation groups did attend to different aspects of experiences with tasks when talking about their individual high- and low-engagement lessons. Again, students' positive or negative responses to lessons seemed unrelated to whether or not the lesson included a contextual task, though several students referenced their favorite lessons by context.

Patterns in student responses to lessons by motivation group. For each focus student, I identified “top” and “bottom” lessons based on their reports of their level of effort and enjoyment in the lesson surveys⁷. The important point in the second theme is that in the more open prompts for reflection on lessons, students almost never talked about the utility or attainment value of mathematics. Rather, they focused on how easy or difficult and fun or boring the task was. How students responded to different lessons, however, was related to students' level of motivation to learn mathematics. More specifically, students in different motivation groups attended to varied aspects of tasks when describing their class experiences in surveys and interviews.

⁷ Note that this process was different than in Chapters 4 and 5, where the analysis was for focus students as a group and included more data sources that considered groups of students rather than students' individual responses.

Low motivation group. Students with low motivation to learn mathematics most often responded to prompts about their reactions to lessons based on how easy they felt the lesson was. How much they liked or disliked lessons was closely connected to how confident they felt in the material or how difficult they found it.

Students' individual low-engagement lessons varied amongst the low motivation group, but they were generally lessons where the students expressed trouble understanding the content. For example, Felix described one of his low-engagement lessons (finding heights using shadows) as "difficult" and likened his experience in the task to "Rugby, because I barely even know what it is" (Lesson 14). Lena responded negatively in her survey to the Bolda Cola lesson. During work time, she commented, "I guess I don't get that," and when the teacher offered a challenge activity, she said, "I don't want a challenge!" (Lesson 4). Emily's lowest lesson was the chocolatey cookies task. While working on the problem, she commented, "I don't know, because...I don't know! I'm better at scale factors than this thing!" (Lesson 15). Later, in the interview, she said, "It was really hard to understand...I'm usually good at math but I did not understand what we were doing today."

The low motivation students' individual high-engagement lessons seemed to be lessons in which they felt most confident. One of Lena and Emily's most highly-rated lessons was Sascha's bike task. Lena struggled at first but began to understand the major concepts. In the summary discussion, Lena shared an idea and Ms. Pearson responded, "So Lena is absolutely correct." In the interview, Lena said, "I found [the task] interesting because I learned a lot...I was putting a lot of work into it and trying really hard" (Lesson 7). Similarly, in the interview Emily commented, "I would say it was challenging, but a good kind of challenging, because I

could understand it.” Though she expressed confusion throughout the small group work time, she eventually grew more comfortable, saying, “this is easy!”

The students in this group also mentioned task structure and/or expectations—which reflect instructional decisions—when describing the lessons they particularly liked and disliked. Lena enjoyed Lesson 2 because she “liked working in groups and making posters.” She even commented at one point in the lesson that making posters makes her “feel smart.” Lena and Emily both disliked the chocolately cookies lesson, during which Ms. Pearson asked students to move into groups to argue for the most chocolately cookie. They agreed that they “didn’t like standing up over there [in the corner of the room] and sharing.” Emily also stated multiple times that she did not like using the chip model because she found it confusing. Taken together, these examples point to low motivation students’ focus on how successful they felt at understanding the material when reflecting on a lesson.

Neutral and mixed motivation group. Like the low motivation group, the students who reported neutral or mixed motivation to learn mathematics sometimes described lessons in terms of their level of difficulty or ease. They focused more, however, on how “fun” or “boring” the lessons were—that is, they attended to their intrinsic value—and for this group, the lessons they described as fun were likely to involve contextual tasks. Also, they often expressed that they liked lessons even when they struggled or found them difficult and disliked lessons when they were too easy or boring. So, these students did not show the same strong correspondence between liking lessons and ease in understanding.

Drayton, for instance, described the lesson in which students estimated the distance across a river as “fun,” even though he struggled with it. During the lesson, he asked, “Hey team? I need help. I’m totally lost” (Lesson 12). Similarly, he described the Wumps lessons as

awesome and fun, saying he loved graphing the Wumps. Yet, again, he expressed having trouble with the task during class. He told his group, “Good thing I got these, because all my other things were wrong.” Later, when the teacher asked him how graphing was going, Drayton responded, “Not so good; I don’t think I’m going to get that [what another student graphed]” (Lesson 10). Lilly also loved the Wumps lessons, describing them as fun repeatedly on surveys, in class, and in the interviews. At one point, she announced, “The Wumps are *amazing!*” (Lesson 10). Jacob’s high-rated lessons included the Bolda Cola and chocolatey cookies tasks. He wrote they were exciting, fun, and not too boring. Like Drayton with the river and Wumps tasks, Jacob struggled somewhat with the cookies lesson but still liked it. At one point he remarked, “this is confusing!” But after the teacher explained it, “the pieces kind of fit together” (Lesson 5).

These students responded negatively to lessons typically because they found them boring. Adelyn described her low-engagement lessons (5 and 8) as boring and anticlimactic. She also said it was hard to focus, she was easily distracted, the material was hard to grasp, and she “didn’t get it” (Lesson 5), indicating her belief in the high cost of engagement in the lesson. Jacob’s negative responses were all to lessons from *Accentuate the Negative*. He likened one lesson to a kids’ cartoon, for example, because it was “boring and for young kids...it was stupid and easy” (Lesson 13).

Finally, some of the neutral/mixed motivation students based their lesson responses on how much they participated in the lesson or on the nature of the lesson activity—whether it was a game, writing on whiteboards, they particularly like graphing, and so on. Adelyn, for example, liked the whiteboards, describing them as “cool” (Lesson 13). Lilly rated Lesson 5 (using the chip model) highly. She described it as interesting, then highlighted her own participation. “I

thought I did good, entered the discussion more than usual. I actually don't talk very much.”

Lesson 13 was similar—she liked the lesson better than others “because she felt useful.”

In sum, students in this group did not necessarily associate easy with “good” and hard with “bad.” Rather, they expressed that lessons that were too easy were boring, and talked about lessons being fun even when they struggled to understand. Like the low motivation group, these students sometimes attended to the nature of the lesson activities. Contexts played a bigger role in this group's engagement, though, such as Drayton and Lilly with Wumps tasks and Jacob with Bolda Cola and the chocolatey cookies.

High motivation group. The students highly motivated to learn mathematics attended to some of the same things in their responses to lessons as the neutral/mixed motivation group. For example, they disliked lessons they found boring. Kim described her low-rated lessons as “not exciting and confusing” (Lesson 1) and “boring” (Lesson 6). They talked positively about lessons they found fun even when they were difficult. McKenna particularly liked Lessons 12 and 13, which she described as “easy to take in, and fun” though she expressed confusion throughout the lesson.

For this group, however, contextual tasks did not play much if any role in their positive or negative responses to lessons. They liked lessons with noncontextual tasks or tasks with peripheral contexts, and did not necessarily like the lessons with highly contextualized problems. This may be related to the fact that, as described earlier, specific contexts did not hinder or support these students in identifying other meaningful applications for the mathematics. They gave very consistent responses to lessons, with Elijah rating most lessons low (no fours for engagement) and Jeff and McKenna describing almost every lesson positively. Most notably, though, the high motivation students explicitly communicated that they liked feeling challenged,

figuring out solutions to challenging tasks, and being active learners with opportunities to work on mathematics.

Elijah, for instance, often said lessons were boring because there was not “enough to do” (e.g., Lesson 7). The lessons he liked, he described as “fast” and “lots of events jam-packed together.” Similarly, Jeff related a lesson on negative numbers to golfing because it was “slow but boring. If you’re playing, it’s actually pretty fun.” McKenna’s favorite part of the Wumps lessons was “figuring out...how to find the x and y —figuring out the rule.” She rated her effort as a 4, saying, “I tried to pay attention and I liked this math class, I wanted to learn more about it” (Lesson 10). Her favorite parts of Lesson 14 were “figuring out the problems, figuring out the heights” and “discussing it so I could make sure I got the right answers.”

So, students in the high motivation to learn group based their responses to lessons on how active they were in the lesson in terms of having opportunities to engage in mathematical thinking and solve problems. This was in contrast to the other groups, whose high-engagement lessons were easy (low motivation students) or fun (mixed/neutral). Although none of the students attended to the utility or attainment value of the mathematics content when talking about their general reactions to tasks, the students with neutral or mixed motivation to learn did seem to be drawn to certain contexts, particularly the Wumps and Bolda Cola contexts. Interestingly, all the students at Pine River responded positively to the Wumps tasks, but note that different motivation groups liked these tasks for different reasons.

Contextual tasks not related to individual high- and low-engagement lessons. As seen in the previous section, another trend in student responses was that across the focus students, their high- and low-engagement lessons included a mix of contextual tasks and noncontextual tasks. That is, some of their high engagement lessons were contextual and some were not; some

low engagement lessons were contextual, some were not. So students' positive or negative reactions to tasks did not seem to be closely related to whether or not the task was contextual nor their underlying motivation to learn mathematics.

For example, Adelyn (who was neutral in both expectancy of success and valuing mathematics) reported two high-engagement lessons. The first was the group poster activity with a peripheral Wumps context, and the second was a whiteboard review activity with no contextual tasks. Her low-engagement lessons both included contextual tasks--“chocolatey cookies” in Lesson 5 and Lesson 8 with multiple contexts (e.g., plane in flight, Jack’s enchiladas), which was a low-engagement lesson overall for the focus students. Similarly, Jeff (high motivation to learn) reported lower-than-typical engagement in a noncontextual lesson from *Shapes and Designs* (Lesson 2) and another with some contextual elements from *Accentuate the Negative*. Two of his particularly high-engagement lessons were when students used similar triangles to: a) find the distance across a river (Lesson 12) and b) to find missing measurements in polygons, a noncontextual task (Lesson 13).

Moreover, most students responded positively to noncontextual tasks. In Pine River, for instance, the five focus students present described Lesson 3 (from *Shapes and Designs*) as “good,” “enjoyable and fun,” “[like eating] steak, because it was super hard to chew or understand but in the end it was like Jell-O, easy and understandable,” and how “at the end we had to finish and I wanted to keep going.” The Southpoint students described the lesson that had no contextual elements as “easy,” “alright,” and “[like eating] oranges—it’s tasty and kept me occupied.” Together, these examples illustrate a lack of pattern between students’ positive or negative responses and the contextualization of the content. Also, students never talked about the

utility or attainment value (or lack thereof) in these open descriptions of their experiences with the tasks, and contexts were not necessary for students to find a task easy or fun.

Several students did, however, identify tasks or content by their contexts when asked about their favorite lesson from the class so far at the end of the semester. Four of the 12 focus students—including students from all three motivation groups—said the Wumps tasks were their favorite by name. They responded with statements like, “I liked the Mug Wump lessons because they were fun” (Lilly), and “Mug Wump because it was entertaining to draw and guess” (Jeff). The Wumps context seemed to be memorable and meaningful to students, and these results show the potential for contexts to anchor students’ classroom experiences. This trend extended to the entire set of study participants, as approximately half of the total students identified a contextual task as their favorite, mostly Wumps or using shadows to estimate heights. To summarize, although results presented in earlier chapters showed that students generally showed high engagement in contextual tasks, it is clear that contextualization is only one factor in student engagement and reactions to tasks.

Results Part 2: Illustrative Student Cases

The purpose of this section is to introduce in greater depth three focus students and provide a fuller picture of their experiences in their 7th-grade mathematics class, including their reactions to and engagement in tasks. I chose one student from each motivation group to illustrate and highlight the themes described in Part 1 of the results: Felix from the low motivation group; Sophia, who expressed low expectation of success but high valuing of mathematics; and Elijah from the high motivation group. Felix and Elijah are good representatives because they articulated fairly typical responses for their motivation group and each represents a different class. I chose Sophia because she was the one student who had a

negative view of herself as a learner of mathematics but highly valued the subject. Drawing on context-related interview and survey responses as well as their contributions in class, I will describe important characteristics of each student, their interests, and noteworthy observations.

Felix—I feel smart on weekends, because I'm not being told I'm wrong!

Felix expressed both low expectation of being successful in mathematics and low valuing of mathematics. In his opening survey, he wrote that he did not have a favorite lesson in 6th grade mathematics and said he “struggled.” His interests outside of school included skeet shooting, making things out of wood, fishing, and knife collecting. Felix had a 504 plan and was labeled by the school as a special needs student. He attended the school’s “math lab” every day to work with an academic aid who also attended his class to work with various students.

Felix was generally quiet in class and got along well with other students in the group. He rarely made it very far through problems, however, or contributed to discussions unless directly asked. On one occasion he was off-task most of the lesson and eventually Mrs. Meyer moved him to a table to work alone.

There were few instances in which Felix attended to the context while solving or discussion problems, though he did use contexts in various ways. When discussing the Mystery Teacher task, for example, he connected the context to the central mathematical idea of the lesson (similarity) during the whole class summary, saying, “The scene in the picture is exactly the same as how it would be in real life, just smaller.” He talked about contexts themselves in the first Wumps lesson by sharing about his favorite video game and commenting on how the characters looked like “double-sided porcupines or hedgehogs.” Later, he used his graph of Glug to check his work. “I feel bad for Glug. His eyes are underneath his nose... Oh wait, three times

five, fifteen!” These examples of his contributions show how Felix did make use of the context when solving tasks though his engagement was generally low.

As with the other students in the low motivation group, Felix did not think the mathematics they learned would be very beneficial. He said, for example, that he would not use what they were learning about polygons “too much outside of school because I’m going into finance” (Lesson 2). His desire to go into finance did not seem to translate into believing that other mathematics content would be valuable, however, since he did not say that any of the other lessons would be beneficial, even the lessons on integer operations that most other students said would help with personal finances. The only time Felix expressed a belief that the content would be valuable was after the lesson on estimating heights of tall objects. He described it as “not really that useful, except in architecture. Tearing down a building, putting it up, measuring how high it is before you tear it down.” (Lesson 14). As described in Part 1 of the results, this one application extended directly from the context as written in the task.

The lessons to which Felix responded most negatively were clearly linked to when he had trouble understanding. He used the following descriptions for the lessons he reported (and I observed) his lowest engagement: “It was really confusing” (Lesson 1), “it was extremely confusing” (Lesson 11), “I found it difficult” and it was like “rugby because I barely even know what it is” (Lesson 14). Note that the last lesson was one where Felix did recognize utility value. Students played a game in another of Felix’s least favorite lessons, and students liked it overall. But Felix called it “cheesy,” and announced during the lesson, “I never win!” (Lesson 5).

One of the lessons Felix responded most positively to was the Mystery Teacher task, which was one of the overall high-engagement lessons. Though he did not contribute much in the lesson, recall that it is the lesson where he shared an important idea during the summary that

linked the context to core idea of lesson. This likely increased his sense of success in the lesson and related to his report of high engagement. Felix's other high-engagement lesson did not involve a contextual task, but did include use of the polystrips manipulative to construct polygons.

Felix's response to the Wumps lessons, which were generally highly engaging for students, was interesting. Immediately after the lessons, he described them as "fun," though he did not rate them particularly high nor did he exhibit high engagement by my observation. He rated his effort and enjoyment as three out of four, saying, "I was engaging in it a lot until I got distracted giving them mustaches" and "it wasn't... exactly the most fun I've ever had in math class." Lilly pushed back on that last comment with "But it was the Mug Wumps! It was the *Wumps!*" and Felix responded, "I know, but in my old school we graphed bigger things, like buildings and machines and stuff. One time we graphed an engine and it was pretty cool." I am unsure what kind of task he might be referring to, but the message was clear—Felix enjoyed the lessons well enough, but they did little to support his valuing of mathematics or the specific topic. In a later interview, some students spoke about how they disliked mathematics and again, Lilly asked, "What about Mug Wump?" Felix replied, "I feel smart on weekends. I feel smart on weekends, because I'm not being told I'm wrong!" Yet, at the end of the study period, Felix identified his favorite lesson to be "Wump—it was easier than the rest of the year." This response indicates that he did recall that he had relative success in the Wumps lesson, and also that the context itself was memorable for him.

Felix is a case of a student who struggled to learn mathematics and did not see much value in learning it. Though some evidence exists suggesting that task contexts supported Felix's work in the classroom, they had little positive or negative relationship to how he responded to a

lesson or how much he valued the content studied. Rather, he focused on the extent to which he could make sense of the mathematics (i.e., how confusing or easy it was) and how successful he felt in the lesson.

Elijah—Math is My Friend!

Elijah expressed both high expectations of being successful in mathematics and high valuing of the subject. His interests included running, soccer, basketball, video games, Science Olympiad, and competing in mathematics competitions. He seemed to love mathematics and did not mind being challenged. On his initial survey, he wrote, “my favorite math lesson last year was when we had to find missing dimensions with shapes when our teacher only give me a percent of how big it is compared to the original.” Ms. Pearson wrote in email communication, “Elijah and I had a discussion today—he’s very task oriented and more concerned about getting his work and homework done than working in a group, figuring things out together, and being further challenged, although he would accept challenging questions.” He was eventually moved to an 8th-grade course after the end of the study period.

In my observation, I saw that Elijah was a strong student and picked up on ideas quickly. As Ms. Pearson said, he did not like working with classmates and was sometimes even condescending or resisted explaining problems and concepts to them. He completed the assigned homework even though it did not count toward his grade and often worked on upcoming assignments during group discussions. Elijah held high social and academic status in the class, though other students expressed that they preferred not to work with him because he made them feel deficient.

During lessons, Elijah used the context to solve and make sense of problems whenever it was necessary or helpful. The fact that he talked about and used the contexts is not surprising, as

he consistently exhibited high engagement in each lesson. In the cola advertising task, for instance, he frequently referenced the two companies in his explanations. A representative example is when he said, “I chose [statement] 2, because it makes it sound like a ton more people liked Bolda Cola...when I see that number I think of a really big number, and I think they must, I think they didn't have that many people. So 5,000 looks like a lot.” Another example is from the bike task. Elijah explained to his group, “What you want to do is finish at the exact same time as Sascha does...so what you're writing down is the miles per hour how fast you should be going.” Although he referenced contexts while working on tasks like in these examples, Elijah almost never talked about the problem contexts apart from the mathematics. The only exception was at the beginning of the cola advertising lesson, when he contributed ideas about familiar commercials that compared two products. This was consistent with his focus on the mathematics and desire to complete tasks.

Elijah communicated in every interview that the content they had studied was beneficial and useful, and he could generate specific and relevant applications for the material. He described scale factors as “Very useful. For almost everything, even if you're just building a table, if you need to scale it down.” For integer operations, he said, “Everybody's going to have to know this. Everybody needs to deal with financial stuff.” He described the “sales rep” example as an application for unit rates. In other interviews, he stated that what they learned was “very helpful for everyday life” and “very useful, because you're constantly getting statistics that get punched into your mind.” So Elijah, like the other students in the high motivation group, generally viewed what they learned in class to be useful and important in one’s everyday life regardless of career path.

Also like others in the highly motivated group, Elijah rated his own engagement consistently across the lessons in the study. Interestingly, though, he reported relatively low engagement, never rating his effort or enjoyment above a three. In over half the lessons he rated his effort as a one and his enjoyment as a two or three, which I believe was his way of saying the course was too easy for him. He did rate two lessons somewhat high; both involved contextual tasks with peripheral contexts (Lessons 2 and 6, which mainly involved going over homework). Elijah connected his positive response to these lessons with how active he could be in the lesson, describing these lessons as “fast” and “lots of events jam-packed together.” He also said, “It’s more fun when you actually do the problems and not just write them down.” Elijah rated one lesson (Lesson 10) particularly low. He saw value in learning about negative number operations but said it was “boring because we didn’t really do anything....we didn’t get to do anything for 40 minutes. I didn’t feel involved.” This was often his complaint about lessons.

Elijah is a case of a student highly motivated to learn mathematics, who believed he would be successful in class and that what they were learning was valuable. Whenever asked, he communicated that the mathematics topic they had studied would be beneficial and useful in everyday life, regardless of one’s career path. Also, he was quick to come up with meaningful applications for lessons. Like Felix, however, these beliefs did not seem to be connected to whether or not a task had contextual elements. Instead, he emphasized the lessons’ cognitive demand, which was related more to the activities and structure of lessons than task contexts.

Sophia—What if I Become a Famous App-Maker?

Sophia was the only student who expressed low expectancy of success in mathematics but high valuing of the subject. In fact, her view of her ability to learn mathematics was one of the lowest of all the students across the two classes, while her valuing was one of the highest.

She listed her interests as music, drawing, riding bikes, and swimming. “Fractions” was her favorite lesson from the previous year because it was “easy and fun.” Sophia also attended the math lab, and occasionally left class during observed lessons with some other girls to work with an academic aid.

I noticed in the observations and interviews that Sophia struggled to understand the mathematics but worked hard toward understanding. She was generally highly engaged, but often in the form of asking questions of or requesting help from Mrs. Meyer and her group mates. Sophia seemed excited when she understood how to complete problems, and appeared pleased when the teacher called on her to share an answer or an idea.

Along those lines, Sophia’s self-reported high engagement and the lessons she responded positively to were those in which she experienced some level of success and enjoyment. Sophia described the lesson with the integer product game as being easy and fun, responding, “I was close to winning!” and “When you have a game, the time just flies.” She rated her effort and enjoyment high but struggled to understand the problem in Lesson 13, asking her peers, “How did you get the answer? I just don't know how to do it!” Later, she talked positively about the lesson and said it was easy. Sophia’s reaction to a task on subtracting integers was particularly noteworthy. She described it as easy, fun, and interesting; then turned to a reflection on her participation. “I was actually participating, like I was talking more.” Her favorite part was “discussing it out loud to everybody.” Sophia showed productive engagement in the lesson and received significant teacher encouragement. Mrs. Meyer asked her to share her solutions in the whole-class summary and publically praised her, saying, “You’re sharing some good ideas.” Later, another student referenced Sophia’s strategy.

On the other end, Sophia described the lesson on estimating heights using similar triangles as “slow and boring.” During the lesson, she said she was confused and did not get the concepts, but in the interview said, “I really didn’t think a lot; I was just bored.” These reflections on the lessons Sophia found most and least engaging show that she attended most closely to her level of participation and how fun she found the task, which was characteristic of the neutral/mixed motivation group. Further, struggling with the content did not deter her from enjoying and putting effort into a lesson.

It is important to note, though, that unlike other students in that group, Sophia’s response to tasks had little to do with their contexts. Her three highest-engagement lessons primarily included noncontextual tasks on integer operations and using scale factor. Her lowest rated lesson—finding heights of objects—had a context central to solving the task, but it did not seem to promote Sophia’s engagement. Thus, it seems task contexts did not support Sophia’s engagement like they did for Lilly, Drayton, and Jacob.

This lack of relationship between contexts and engagement may be because of Sophia’s beliefs in the general importance and value of learning mathematics. More similar to the students in the high motivation group, Sophia expressed in each interview that she believed the content was useful and beneficial outside of school and offered applications for the content. For instance, after a lesson from *Shapes and Designs* on interior and exterior angles, Sophia argued that the lesson was important for “If you, when you’re older, get a job in carpeting and you have to measure angles and stuff” (Lesson 2). Or, after playing the integer product game, said it would be beneficial in college and that “You still have to use numbers at any job, even if you have to work at McDonalds or something! Yeah, you use negative and positive numbers because some people are short the money. They would have to pay you the next time” (Lesson 7). Sometimes,

though, the applications Sophia suggested were quite vague or somewhat irrelevant. Similar figures, she said, would be useful if you worked at McDonalds, “Like if you order some meat or something.” She then asked, “What if I become a famous app-maker, and I made the Wumps game?” to which Lilly responded, “That would be awesome!” Finally, she suggested that estimating heights of objects would be helpful in “sports.” In these examples, it was unclear how the mathematical topic would be useful in the situations Sophia identified, but the examples are consistent with the high value she placed on mathematical ideas.

In sum, Sophia is a case of a student who learns mathematics with difficulty, but who believes it is worth the effort—that mathematics is an important and useful subject. She consistently communicated this high valuing of mathematics, particularly in the interviews when asked about the usefulness of particular topics. Her responses, however, were not closely related to whether or not lessons included contextual tasks, and the extent to which she reflected positively on lessons reflected her level of participation and the intrinsic value she placed on the activities over her perceived utility value of the mathematics content.

Discussion

An analysis of students’ responses to tasks based on surveys, interviews, and class contributions across the study period indicated that task contexts had a fairly weak relationship with the value focus students found in the mathematics content and how positively they responded to lessons. Yet, there were noteworthy patterns in what students attended to in their responses, and certain contexts stood out as particularly meaningful for some students. Based on these findings, I argue that contexts can play different roles in students’ response to mathematics tasks. A particular context may engage students by offering intrinsic value to lessons, or it may support their understanding and problem solving. Although it is highly possible that certain

contexts can promote students' motivation to learn by supporting their valuing of the subject, little evidence from this study exists to suggest this is the case for CMP tasks. These roles are not mutually exclusive, and contexts may not have the effect anticipated by curriculum authors or teachers.

Contexts, Value, and Application

Hidden applications. An exploration of students' beliefs about the attainment and utility value of the mathematics they learned revealed that focus students as a group consistently described potential applications (some more reasonable than others) for the content they learned in lessons. Responses about value and applications for mathematics had little if any relationship to whether students had engaged in contextual tasks, however, and differed between motivation groups. Money-related contexts seemed especially effective in supporting students' beliefs that rational number operations are valuable in their everyday lives. So although this study showed that contexts can be engaging for students during in-class work, these students' work with contextual tasks did not appear to translate to greater recognition of the value of the content.

Students' varied responses regarding the usefulness and potential application for what they learned—and the fact that contextualizing the material does not seem particularly helpful—might not be of concern. As Otten (2011) and others have argued (e.g., Wu, 1997), mathematics educators should not feel obligated to have an application ready for every topic. Content in the curriculum can serve multiple purposes, such as developing skills or ways of thinking to support learning of future content. The mathematics we teach does not necessarily have or need a direct application. No other subject has quite the same demand to answer the question, “when will I need to know this?” Expecting contextual problems to bear the responsibility to answer that question, or for students to glean much meaning from the stories, may be unrealistic.

Yet, the material students encountered in 7th-grade mathematics had applications far beyond what was represented in the classroom problems. For instance, most people use rational number operations in their careers and everyday life in a broad range of contexts, and these skills are supported by working with positive and negative numbers in school mathematics. Further, these concepts support quantitative and algebraic reasoning necessary for success with future mathematics topics and courses, interpreting statistics, and so on. Similarity and scale factor are used in numerous situations, including engineering, construction, architecture, design, art, and travel. These many applications remained largely hidden from the students in the study, indicating that students do not transfer task contexts to a belief in the value of the content. It may be that the students simply do not have the life experiences on which to hang these applications. Boaler suggested this idea as well (1993):

[C]ontexts may be useful in relation to learning transfer even though contexts as they are generally used are not useful, and...factors which determine whether the context is useful or not are numerous and complex and have little to do with a description or depiction of real world events which students will eventually encounter. (p. 13)

So although the mathematics students are learning is useful and used to solve problems outside of school, contextualizing school mathematics problems do little to expose students to these applications.

Differences related to motivation group. Moreover, a relationship exists between how students with different levels of motivation to learn mathematics respond to problem contexts, with highly motivated students in this study being better at generating meaningful and relevant applications for specific content than students with low motivation to learn. It is possible, therefore, that students are motivated in part because they can see the “mathematical horizon” (Ball, 1993, p. 376), look beyond a given situation, attend to more general learning goals, and transfer the use of mathematics introduced through a specific context beyond that context. This

points to the potential importance of students' future goals, personal experiences, and beliefs about themselves in relation to schooling in the relationship between student motivation to learn and engagement with contextual tasks.

Based on this study, it is impossible to clarify the direction of influence in this relationship. That is, are motivated students like Elijah and Jeff more disposed to think about and come up with applications for what they learn? Or does this inclination promote valuing the subject and thus lead to increased motivation? And the same for low motivation students—if students in a problem-based curriculum interpret problem contexts literally, as Felix and Lena did, does it hinder them in seeing personal relevance in the content? Or does low valuing of mathematics lead to a generalized perception that school mathematics is not useful? These are open questions, though other researchers have noted how students relate to and make use of contexts differently (Christiensen, 1997), particularly along lines of socio-economic status (Cooper & Dunne, 1998; Lubienski, 2000). There might be interplay, then, between students' motivation to learn, socio-economic status, and attention to contexts while solving problems and reflecting on ideas in mathematics.

Thus, if we want to build on the potential of contextual tasks to promote valuing of mathematics, we may need to be more explicit with students about contexts—what they mean, the role they play in problem solving, and how the context may point to realistic applications for the mathematical ideas (Jackson et al., 2012, 2013; Middleton & Jansen, 2011; Sullivan, et al., 2003). It is also possible that other types of tasks such as those with community-based or social justice contexts—which I did not observe in this study—have greater potential to support students' beliefs in the value of mathematics. I am not suggesting, of course, that all contextual tasks will be engaging and/or motivating for all students, but that mathematics educators and

curriculum designers need to be thoughtful about intent when it comes to writing and enacting contexts.

Money contexts as motivators. The finding regarding students' responses to money contexts was somewhat surprising. Those contexts supported students' valuing content in *Accentuate the Negative* lessons (rational number operations), but the intent of these contexts seemed to be to support students' problem solving rather than catching students' interests or motivating them to learn. Consider an example typical of the contextual tasks in that unit: "Jeremy had \$7 on Saturday. He earned \$5 walking his aunt's dog and spent \$10 going to a movie at the theater. Find how much money Jeremy has now, and write a number sentence for this situation." From my perspective, there is nothing particularly interesting or relevant about the storylines in these problems (I imagine most people do not normally write number sentences when they encounter these problems in their everyday lives), and none of the lessons in this unit were found to be highly engaging for students. Representing authentic applications was not the intention of the authors, either. In the teacher's guide for the unit, the authors state that weather, money, and game score contexts are used to give students opportunities to build on informal integer operation strategies (Lappan et al., 2013).

Yet, the connection students made between rational number operations and future careers and everyday matters related to money seemed to promote beliefs in the value of the content. One possible explanation is that the students were attracted to the accessible but seemingly adult financial scenarios, which would be consistent with Jansen and Bartell's (2011) finding that some middle school students preferred adult contexts such as mortgage rates and rates on car loans. Whatever the reason, it highlights the point that task contexts may have an effect on students quite different than intended by teachers or curriculum authors.

Contexts, Expectations of Success, and Intrinsic Value

When reflecting on lessons and the factors that influenced student engagement, students generally focused on the level of ease and fun they had in the lesson and not on attainment or utility value. Again, contexts did not seem to play a role in students' reactions to lessons, though these results were somewhat different based on their underlying motivation to learn. On one hand, this trend may be unexpected in light of the findings presented in previous chapters. Specifically, all high-engagement lessons included contextual tasks as the primary activity and half of the low engagement lessons had only noncontextual tasks. Of course, these earlier findings were for engagement across each group of focus students rather than for individual student engagement.

On the other hand, students' focus on feelings of success in lessons was not surprising given extant literature. Brophy (2008) wrote that research has generally focused heavily on expectations of success over how students value what they learn. Motivation theories such as self-attribution theory (e.g., Weiner, 1985), self-efficacy theory (Pajares, 1996), and goal orientation theory (e.g., Ames & Archer, 1988) also emphasize students' beliefs about themselves as learners of mathematics over beliefs about attainment or utility value. It might be that existing theory and literature reflects what students tend to communicate about, or what is most apparent to them, which seems to be how successful and able they feel in mathematics. The trends in students' responses are also consistent with a theme in literature on motivation to learn that students need some expectation they can be successful in order to be motivated in the mathematics classroom (Middleton & Jansen, 2011; Middleton & Spanias, 1999).

Together, the findings suggest that not all contexts have the same potential to engage students, and that different students are attracted to different types or aspects of tasks and

activities. This backs the assertion in the literature that assuming contextual tasks are motivating for students simplifies students' diverse experiences, goals, beliefs, and interests (e.g., Boaler, 1993, Chazan, 2000; Middleton & Jansen, 2011; Sullivan et al., 2003). We should not expect all students to respond the same way to contexts. Though this study did not consider students' racial, ethnic, and cultural experiences and thus cannot speak directly to arguments that contexts could link content to these personally relevant experiences, I saw that even within this small group of students who were diverse in terms of their motivation to learn mathematics attended to different aspects of tasks and lessons. Although contexts may play a role in helping students link school mathematics and the "real world," of primary importance is developing personal meaning of mathematical ideas through exploring their own solution strategies and recognition of "the individual nature of students' learning" (Boaler, 1993, p. 16). For low motivation students, this personal meaning might involve a stronger understanding of the material, while for high motivation students, this might reflect more active engagement and solving challenging tasks. Of course, several other factors may influence how students with different levels of motivation to learn respond to mathematics lessons, including motivation-related beliefs about the risks and benefits associated with classroom participation (Jansen, 2006).

Not all students responded positively to all contextual tasks, but for these twelve students, contextual tasks did not turn them off, either. They were not the "hated word problems" (Thomas in Thomas & Gerofsky, 1997, p. 21) Students took contextual tasks in stride, accepting them as a regular part of their experience in the mathematics classroom. Contextual tasks *were* a regular part of their experience, as all of the focus students but Drayton were in their second year of CMP. Some contexts were particularly enjoyable for most students (e.g., Wumps, Sascha's bike trip, and Bolda Cola advertising), but for the most part contexts did not seem to play a major role

in how students viewed tasks. This is likely because of students' frequent and consistent encounters with contextual tasks as the main lesson activity in the CMP curriculum, versus application problems that come at the end of assignments after "naked" number tasks. The fact that students referenced their favorite lessons by context also indicates that these storylines helped topics to "stick" in students' minds. This suggests, again, that contexts helped anchor students' understanding, and reflects the anecdotal claim by the curriculum authors that CMP students refer to concepts and strategies by the problems in which they encountered them. (Lappan, Phillips, & Fey, 2007)

Conclusion

Students' experiences with individual mathematics tasks are complex and varied. Evidence from this study suggests that contexts influence how students solve problems and engage in tasks. But there seems to be a weaker connection between contexts and what value students see in mathematics or how successful they felt they were in learning. These findings may be informative to teachers as they consider how to implement contextual tasks and to curriculum designers as they consider the purposes and goals of contextual storylines in mathematics tasks. In the next and final chapter I return to the research questions and propose implications of the results discussed here on contextual tasks and student motivation to learn, along with earlier results on the relationship between contextual tasks and lesson engagement.

CHAPTER 7

CONCLUSIONS AND IMPLICATIONS

With this study, I set out to explore the relationship between contextual tasks and student engagement and motivation to learn mathematics. Specifically, I intended to determine characteristics of contextual tasks that were particularly engaging and those associated with low student engagement in middle school classrooms in which contextual tasks were used on a frequent and regular basis. To close the presentation of results and the discussion on the motivational potential of contextual tasks, I return to the research questions and summarize the main arguments and takeaway points from this investigation.

Potential of Contextual Tasks to Motivate and Engage

Returning to the Research Questions

To determine features of contextual tasks that were particularly engaging or disengaging, the first research question was: *What characterizes the contextual tasks as written in lessons during which students show particularly high and low levels of engagement?* As discussed in Chapter 4, I found that some of the characteristics I had focused on, such as level of authenticity and personalization, seemed to have little bearing on student engagement in tasks. Contextual tasks in both the high and low-engagement lessons shared many of the same characteristics—they were not personalized or community-based, some were adult-oriented and some were student-oriented, and they represented a range in terms of authenticity and centrality. What seemed more important in engaging students was the role contexts played in problem solving. The high-engagement lessons had contextual tasks that were more open-ended modeling tasks in which the context was at the root of the problem, where students were trying to answer questions within the problem scenario. Determining the identity of the Mystery Teacher, identifying which

characters were Wumps and which were impostors, analyzing advertisements for Bolda Cola—these contexts seemed to be most engaging for students, allowing for flexible thinking about the mathematics and the use of the context in tandem. Most of these tasks came early in units, when students were just beginning to explore the mathematical ideas and building their understanding on informal, everyday reasoning.

The second research question asked: *What characterizes the enactment of contextual tasks, including instructional practices and student attention to context, in lessons during which students show particularly high and low levels of engagement?* In Chapter 5, I discussed how in high-engagement lessons, students attended more to context (i.e., a higher percentage of their engagement was related to contexts), and they were more likely to link the core mathematical ideas to the problem scenario. Student attention to context was related to teacher attention to context—teachers talked about the contexts more, and in more varied ways, in higher engagement lessons. This suggests students are sensitive to teachers’ cues as to how important or interesting a context is.

Finally, I asked, *What factors of motivation underlie student engagement relative to the contextual tasks used in class?* I explained in Chapter 6 how students talked about the value of the mathematical content they learned, but what they attended to in tasks focused far more on how easy (hard) or fun (boring) they found the material. These factors had little relationship to whether or not lessons involved contextual tasks. Interestingly, though, students’ underlying level of motivation did seem to have bearing on how students perceived problem contexts, and how they perceived contexts relative to the value of the mathematics content. The highly motivated students could come up with more relevant and varied examples of applications for the content, and these applications were not as closely linked to contexts as they were for less

motivated students. It was the neutral/mixed motivation group of students, however, who seemed the most interested in the contexts themselves and talked about them when reflecting on tasks.

So What's the Story on 'Story Problems'?

Mathematics education literature presents different beliefs and perspectives regarding the motivational potential of contextual tasks. Contextual tasks are often described as being interesting or motivating to students (e.g., Chapman, 2006; Meyer, Dekker, & Querelle, 2001; Middleton & Jansen, 2011; Mitchell & Carbone, 2011; van den Heuvel-Panhuizen, 2005), but researchers and teachers have challenged that notion (e.g., Boaler, 1993; Chazan, 2000; Sullivan et al., 2003; Verschaffel et al., 2000). The purpose of this study was to explore a more nuanced understanding of the relationship between contextual tasks and student engagement and motivation. What, then, can we conclude?

It is important to interpret the findings while keeping in mind the nature of the tasks in the study. I considered lessons with tasks from the CMP curriculum—some were imaginative and whimsical, others were realistic; some were based on experiences a young teen might encounter, others were based on more adult experiences. Most of the tasks bore little resemblance to classic story problems, but as part of a widely used, nationally published curriculum, they also were neither personalized or based on community-specific scenarios. Thus, although I observed a variety of contextual tasks, they were still a small subset of the tasks used in school mathematics.

To summarize the whole of the findings and core arguments, contextual tasks of the types observed in this study can be cognitively and emotionally engaging for students. This study also offers some clarity about when and how contextual tasks might be most likely to engage students in mathematics. Open-ended modeling tasks that offer multiple ways to draw on contexts while

solving with contexts that are meaningful to students may have the most potential for promoting engagement. The results for high- and low-engagement lessons in this study suggests that how these tasks are enacted matters—students respond best when teachers attend to and highlight the contextual storylines in a variety of ways through out the lessons. Students’ attention to contextual tasks indicated that contexts can promote student engagement by supporting students’ entry into and work on the problems, by catching students’ interest, and by anchoring students’ understanding of the core ideas to something familiar to them. Based on the findings in Chapters 4 and 5, Figure 8 offers some questions one might consider when designing or using contextual tasks if the context is intended to engage students.

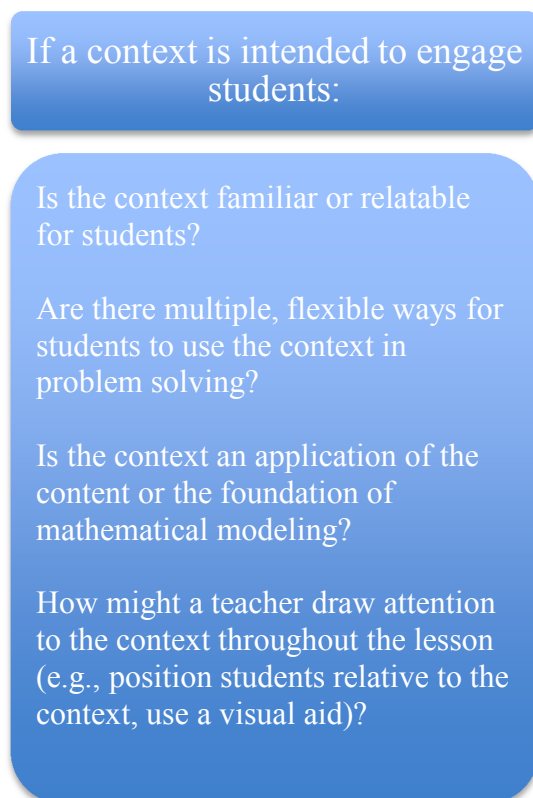


Figure 8. Questions to consider when designing or using contextual tasks to engage students based on results from high- and low-engagement lessons.

Contextual tasks of the type observed in this study, however, might not have the same potential to motivate students to learn or influence how they value mathematics. What students

communicated about their responses to tasks indicated that contexts did little to promote positive beliefs about the value of the content they learned for the tasks in the lessons I observed.

Influencing these beliefs may depend more on contexts that are personally relevant, community based, or address social justice issues. In the next section, I address this limitation and suggest ideas for further study.

The results suggest, as others have argued (Boaler, 1993; Walkington et al., 2012), that the opportunities students have to make meaning and sense of the mathematics are of great importance. The contextual features of tasks can serve to engage and motivate students to the extent they support students in developing understanding that is personally meaningful. We should not assume, then, that all contextual tasks can be engaging and/or motivating for students. Nor should we assume that noncontextual tasks are intrinsically less engaging or motivating.

The findings do emphasize a need to be thoughtful about intent when it comes to creating and using contextual tasks by clarifying the role of the context for ourselves (and, when appropriate, for students) when planning and enacting a task (Sullivan et al., 2003; Jackson et al., 2013). For instance, if the purpose of a context is to support student learning (e.g., temperature change as a context for adding negative numbers), it should not necessarily be expected to promote student engagement. Or, like some of the contexts in the study, a context could have potential to engage students but might not promote positive motivation-related beliefs. The purpose of a context can guide task development and implementation. Accordingly, Figure 9 outlines three potential purposes contexts serve in school mathematics as suggested in extant literature (e.g., Carraher et al., 1985; CCSSI, 2010; NCTM, 1989, 2000, 2009; van den Heuvel-Panhuizen, 2005, Verschaffel et al., 2000; Walkington et al., 2012). It builds on Figure 8 by offering questions to consider when using contextual tasks to motivate students and support

students' problem solving. These considerations do not follow directly from the results of this study, as I found little relationship between contextual tasks and students' motivation-related beliefs, and investigating students' problem solving and learning was outside the scope of this study. Rather, the questions are based on implications of theoretical and empirical literature (e.g., CCSSI, 2010; NCTM, 1989, 2000, 2009; Jackson et al., 2012, 2013; Wigfield & Eccles, 2000).

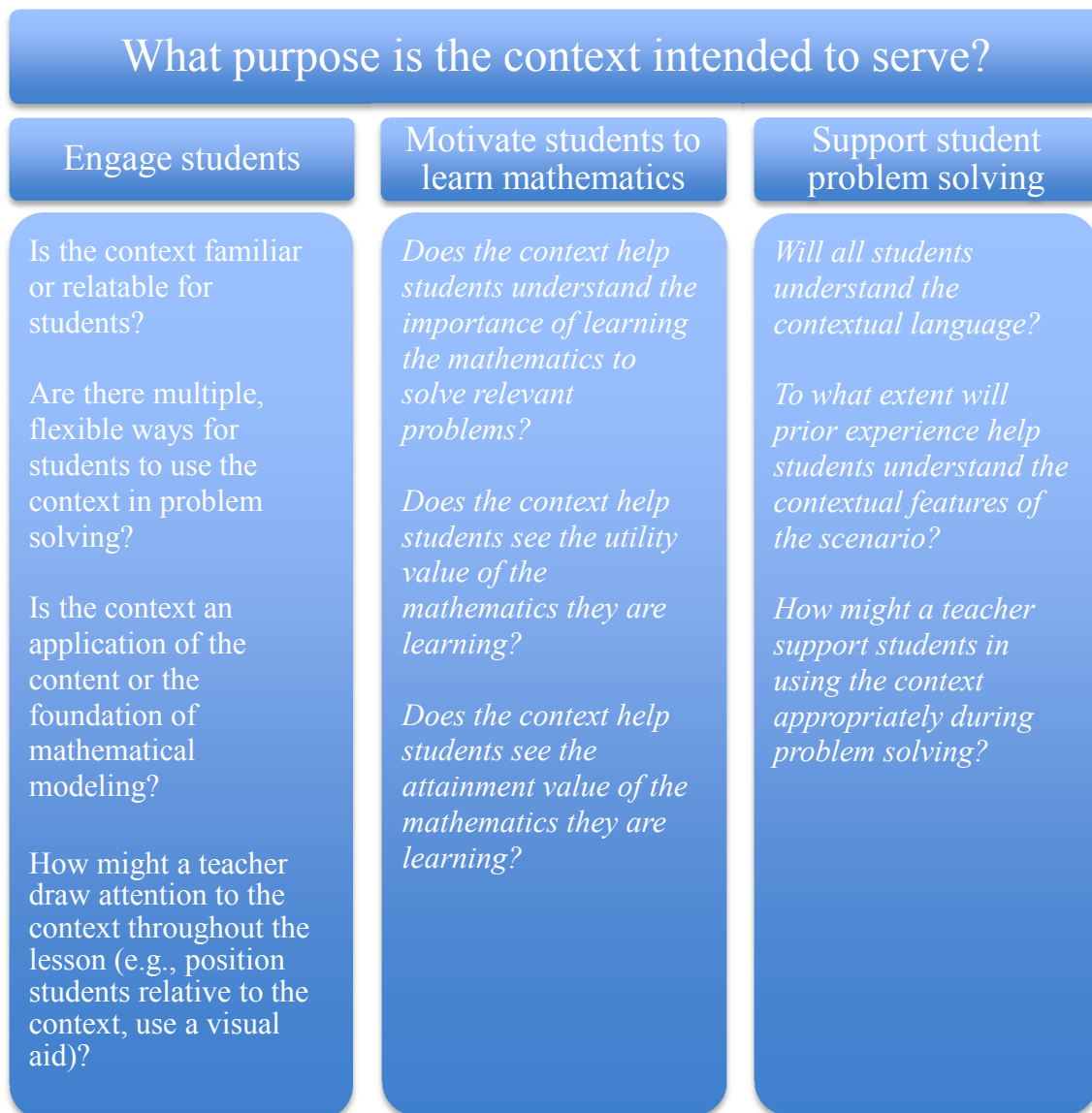


Figure 9. Purposes of contextual tasks and questions to consider when using them to serve these purposes. The first column follows from the findings of the study. The second and third columns are italicized to show these are my suggested questions for consideration based on extant literature.

The purposes of contextual tasks included in Figure 9 are not mutually exclusive. We know, for example, that students' learning experiences are cumulative and build into long-term motivation patterns (see Middleton & Jansen, 2011, for a discussion of this topic), so frequent experiences where students are engaged in mathematics because of an interesting context might lead to increased motivated to learn. Or, if a context supports students' problem solving, they are more likely to engage in the lesson (e.g., Rivet & Krajcik, 2008).

Limitations and Directions for Future Research

Of course, one needs to consider the results in light of limitations of the study, particularly the choice to use CMP classrooms. CMP afforded confidence that I could observe many contextual tasks enacted over several different mathematics concepts. Yet, the types of contexts encountered in the observed lessons represented just a part of the full spectrum of contextual tasks used in school mathematics. On one hand, many CMP tasks are somewhat of a "new breed" of contextual tasks that reflect few of the characteristics of traditional story problems. On the other hand, I expected teachers to use more personalization or to refine the written tasks into more community-based contexts based on extant research (Wernet, 2011), and these practices rarely occurred. This may help explain why I found that different types of contexts did relate to different levels of student engagement. Student motivation might have been better promoted through different types of contexts, such as personalized or community-based contexts, by supporting beliefs in the attainment and utility value of the mathematics.

Furthermore, the findings have limited generalizability beyond CMP classrooms. Most of the students in this study were in their second year using CMP and were used to working on contextual tasks as a frequent core activity in the mathematics classroom. Students in classrooms with more traditional curricula, who do not engage in contextual tasks as the main lesson activity

on a regular basis, may respond quite differently to these types of tasks. Jackson et al. (2013) made a similar argument about their findings regarding the relationship between task launches and summary discussions—that the ways teachers launch tasks (including their attention to contexts and contextual vocabulary) is probably more important in cognitively challenging tasks aimed at developing conceptual understanding. Thus, future research should include classrooms using diverse curricula, including teaching for social justice lessons and more traditional mathematics curricula. Also, participants should represent more diverse age, racial, ethnic and economic demographics than those in this study. The results and questions raised in this small-scale study should be explored with larger number of students or over a greater number of lessons to lessen effects of the numerous factors related to student engagement and motivation.

Part of this broader research might include an investigation of the intersections between student motivation and engagement in contextual tasks and student characteristics such as future goals, general beliefs about schooling, identity, gender, race, ethnicity and socioeconomic status. This would allow us to answer open questions about how contexts that are immediately personally relevant for students might help to connect mathematics content to racial, ethnic, and cultural experiences (Nasir et al., 2008; Tate, 1996) or how contextual tasks that do not relate to students' experiences and goals may alienate and exclude students (Middleton & Jansen, 2011; Sullivan et al., 2003). How can we interpret, for example, the fact that Sophia twice generated applications for mathematics related to working at McDonalds, while Elijah and Jeff (both high motivation students) offered examples such as “sales rep,” packaging engineering, banking, and drafting? Similarly, though it was not the focus of this study, instances in which teachers brought attention to students' work seemed to promote positive responses to lessons. Analyzing the data with a different theoretical lens such as self-efficacy theory or identity theory would likely yield

different perspectives on students' classroom experiences with specific mathematics tasks. Potential studies could more closely investigate engagement with contextual tasks and student motivation mediated by other student characteristics as well as interactions with teachers.

Curriculum analysis is another direction for future research. As discussed below, curriculum designers should clearly communicate the intended purpose(s) of problem contexts and support teachers in making instructional decisions around contexts. My experience teaching CMP indicates that the curriculum provides some support in implementing contexts, but analysis of the teacher materials was outside scope of this study. Comparing mathematics textbooks in terms of the guidance provided teachers for using contextual tasks would provide insight on the role of teachers' guides in whether and how teachers attend to contexts. This research could ultimately inform mathematics teacher education.

Finally, this study focused on cognitive and emotional engagement, but certain engaged behaviors are likely more productive or of higher quality than others, and this study did not capture those nuances. For example, a student posing a relevant question because she does not understand how to start a problem may be qualitatively different than contributing a meaningful mathematical idea, and I counted both as evidence of cognitive engagement. Future studies might differentiate between specific engaged behaviors for a more in-depth understanding of the relationship between working on contextual tasks and student engagement.

I propose three potential studies as the next steps to follow up on this research. The first is really a set of studies to check the generalizability of these results in a broader range of settings. Multiple-case studies analogous to this one (comparing student engagement across lessons) could be conducted in elementary and high school mathematics classrooms in which contextual problems are a significant part of the curriculum to see if results on student

engagement and motivation extend to other age groups. Similarly, a multiple-case study in classrooms using more traditional mathematics curricula would offer insight into students' experiences with a range of contextual tasks. Second, an action research study would be appropriate to address the original intended question of this study regarding differences in context types such as personalized/non-personalized and student/adult-focused. In my own classroom, for instance, I could modify task contexts according to my students' interests or community needs without introducing other novel aspects of tasks and thus more directly investigate the relationship between certain characteristics of contexts and student engagement. Lastly, I suggest a longitudinal study of a small number of students that addresses the relationship between aspects of students' identities, engagement and motivation factors, and students' experiences with contextual tasks.

Implications for Research and Practice

Research

This study offers a set of research tools for measuring student engagement in individual mathematics lessons that were reasonably valid, reliable, and efficient. The student and teacher surveys and observation tools developed have potential for future research on how tasks or other features of lessons relate to student engagement, an area of research with many questions to investigate. I encourage others to refine and revise these tools to serve specific purposes of prospective studies, including a larger scale for the lesson-specific surveys to allow more variation in student and teacher responses.

Further, the result of identifying high- and low-engagement lessons can inform considerations of data sources when studying student engagement. Specifically, there was a fairly low association between the student reports and the counts of evidence of student

engagement across the 14 lessons at each school. The literature on researching student engagement calls for the use of multiple data sources, including student reports and observations, to provide a detailed and multifaceted interpretation of engagement (Fredericks et al., 2004; Fredericks & McCloskey, 2012). My findings, however, highlight the importance of: a) identifying which vantage point(s) and measures will be weighted most heavily in case of disagreement, and b) carefully selecting lessons when using observations. If observations are used to make comparisons across lessons, then researchers should strive to select lessons that are similar in terms of structure, timing, and activities. Counts of engaged behaviors seemed more sensitive than other measures to differences in these factors, including, for example, the amount of time spent in small groups.

My experience conducting the research also highlighted the inherent difficulty of gauging engagement via observation. For example, I had noted Felix's particularly high engagement in a Wumps lesson while observing because he appeared determined to finish graphing, working into the whole-class summary. In the interview, however, I learned that he had been drawing mustaches on his characters and not following the discussion. Again, this should emphasize the value of multiple data sources to make the best possible interpretations of student behavior and responses to tasks. Moreover, data collection technologies such as video cameras in eyeglasses or hat brims (Chval, Pinnow, & Thomas, 2014) or Livescribe Smartpens™ might be appropriate for capturing student engagement in classroom observations.

Curriculum Design

The implications of the study results for curriculum design are similar to those for instruction, but begin with determining whether or not a context is appropriate for a problem given the learning objectives of a task, lesson, and unit. If a task is to have a context, it should

serve a clear purpose (or purposes). If that purpose is to promote student interest or engagement, one needs to consider the nature of the context and how students will be expected to use it. The fact that students were most engaged in lessons with open-ended tasks that offered opportunities for students to draw on the context in multiple ways while problem solving suggests that giving these types of tasks a regular role in mathematics curricula may promote student engagement. Many modeling tasks fit these characteristics. Mathematical modeling is a Standard for Mathematical Practice in the Common Core State Standards, making it a recommended practice throughout the curriculum and grades. I encourage curriculum writers to consider the potential of modeling in promoting not only mathematical proficiency but also student engagement. The least engaging lessons in this study had tasks that were noncontextual, had contexts peripheral to problem solving, or were application problems that closely resembled more traditional story problems. Such contexts might be completely reasonable in achieving the mathematical goals of a task, but the data challenge the notion that such contexts would go far toward promoting students' cognitive and emotional engagement.

The potential of contextual tasks to engage students is boosted when the contexts are meaningful to students. Results suggest that problem storylines do not need to be realistic, but should at least be accessible to students. Every effort should be made to ensure that contexts are imaginable (Van den Heuvel-Panhuizen, 2003) for diverse groups of students in the appropriate age range. Also, although it was not a focus of the study, the most engaging tasks had strong visual elements in the form of photographs, cartoons, graphs, or introductory launch videos. So these elements seemed to emphasize and clarify contexts in ways that supported student engagement.

Teachers' attention to context can also enhance the engagement potential of contexts; in the next section, I discuss specific strategies we can employ to make contexts more meaningful for students. Thus, like teachers with their students, curriculum designers may need to make the purposes of contexts explicit for teachers to guide their decisions about implementation.

Teachers' decisions regarding context would be easier to make and likely be more effective with clear communication from the authors about the intent of context as written.

Instruction

The implications for mathematics teachers and the teacher educators who support them follow directly from the findings and central arguments. Engagement and motivation to learn are issues directly related to our practice. As I have been reminded of on my return to the middle school classroom after finishing this project, we can lead students to the “perfect” task, but we cannot make them engage with it. This study offers support for one promising way to engage students in thinking about mathematics and even enjoy the process. Incorporating open-ended contextual tasks with a meaningful storyline can promote student cognitive and emotional engagement, even when implemented on a regular basis (thus decreasing the effect of novelty). Further, contexts do not have to be personalized or community-based to promote widespread engagement. Imaginative contexts have potential to engage, but any context needs to be accessible to and meaningful for students. Because no widely published curriculum can match all students' experiences and interests, some of the responsibility to make contexts accessible and meaningful falls on teachers.

When preparing to teach a contextual task, the first thing to consider is the intended role of the context relative to the mathematical goals of the problem as in Figure 9, and determine the extent to which it helpful or necessary for students to attend to the context. Once a teacher has

decided the role the context should play, they can plan how to launch and use the context throughout the lesson based on knowledge of their students. The purpose of the context may need to be made explicit to students, through statements such as, “I know this situation is not very realistic, but it will help you think about how to write an equation,” or “This problem shows how important exponential functions are in understanding the spread of disease.” If the goal of the context is to promote students’ motivation to learn, teachers should highlight what the context shows about the usefulness and application of the content—a practice I rarely observed in this study, and the results showed that contexts did not necessarily help students (especially those who already had low motivation to learn) note meaningful applications of the mathematics.

Being explicit about the nature of the problem context can also help toward resolving equity issues presented by tasks (Sullivan et al., 2003) by supporting students’ access to the mathematics in the problem. Teachers can identify what terms or aspects of the context may need to be discussed and what prior knowledge students bring to bear (Jackson et al., 2012, 2013). These decisions need to be made as part of a complex web of instructional decisions. Jackson et al. (2013) put it well:

The scenarios could lend themselves to extended talk about a number of contextual features, which many or may not be critical to solving the task...Clearly, time is of the essence in classroom instruction; therefore, teachers need to make judgments regarding what to focus on in the setup. These judgments must be made against a clear set of mathematical goals for instruction and knowledge of what is likely to be unfamiliar (contextually, mathematically, and linguistically) to students. (p. 656)

These decisions about how to draw on the context extend past the launch phase. If the purpose is to support student engagement or motivation to learn, the results indicate implementation of contexts is important across the lesson. Drawing students’ attention to the context in a variety of ways in class discussions and while supporting student work on the task can influence the way students use and attend to the context, and promote their engagement in tasks overall.

Final Thoughts

Contextual tasks, in a variety of forms, have probably been a part of mathematics education since its inception. They are unlikely to go anywhere, as leaders in mathematics education have advocated for increased emphasis on mathematics problems drawn from real-world scenarios and tasks that promote mathematical modeling and quantitative reasoning (e.g., NCTM, 2000; CCSSI, 2010). Researchers, teachers, and curriculum designers need to continue to think about how to support students' work in contextual tasks if that work is to lead to robust understanding. In particular, we should consider the issues of how to promote students' productive engagement in thinking about these problems, and how students' experiences with the tasks might motivate them to learn mathematics.

If nothing else, the results presented here provide an existence proof that students can engage meaningfully in contextual tasks in a way that supports positive affect. Yet, we should always be cognizant of the purpose of developing and using contexts for school mathematics, recognizing that not all contextual tasks have the same potential for promoting all students' engagement or motivation. Refining our intentions and decisions involving contextual mathematics tasks might ultimately lead to more students choosing to learn and use mathematics, as they "learn it with understanding and see its beauty and the possibility of applying it to matters that interest them, including games as well as more practical matters" (Willoughby, 2010, p. 83). For me, that is always the goal.

APPENDICES

APPENDIX A

SAMPLE LESSON MODIFIED BY MS. PEARSON

2.3 – Scale Factors

Name _____ Hr__

Stretching and Shrinking

Facilitator: Make sure everyone knows the instructions and that everyone does all parts of the problem. It will help to read all the directions first before beginning

Recorder/Reporter: Your group needs to organize a poster with all your results. Your poster needs to have everyone's work, be well organized, and use math tools, arrows, and/or colors to show your thinking.

Resource Manager: Manage materials needed. Make sure all questions are group questions! Don't let your group stay stuck – call me over!

Team Captain: Make sure everyone understands the solution to the problem. No talking outside your group!

Your group will work together to explore properties of similar figures and their scale factors. On the resource paper, there are many rectangles and triangles. Use them to answer the following questions. Put your answers on your notepaper. You will create a group poster after.

The rectangles represent the mouths of some Wump family members and some imposters. The noses are represented by the triangles.

1. Decide which pairs of rectangles are similar and find the scale factor for each pair.
2. Decide which pairs of triangles are similar and find the scale factor for each pair.
3. Pick one pair of similar rectangles and one pair of similar triangles. Use the scale factors you found from #1 and #2 to predict the relationship between the perimeters for each pair of similar shapes. Explain. (You do not need to find the actual perimeter, just talk about the relationship between the perimeters of the two similar shapes.)
4. After studying the noses and mouths in the diagram, Marta and Zack agree that rectangles J and L are similar. However, Marta says the scale factor is 2, while Zack says it is 0.5. Who is correct? How would you describe the scale factor so there is no confusion?
5. On graph paper, draw a rectangle that is similar to rectangle J, but is larger than any rectangle shown in the diagram. What is the scale factor from rectangle J to your rectangle?
6. Draw a triangle that is not similar to any triangle shown in the diagram. Why is it not similar?
7. Draw a rectangle that is not similar to any rectangle shown in the diagram. Why is it not similar?
8. Explain how to find the scale factor from one figure to a similar figure.

When EVERYONE is finished, organize your work into a large poster. You can glue the shapes directly onto the poster. Your poster should clearly communicate your solutions and justifications! Make connections between ideas, the shapes, and your justifications with color, arrows, or other tools.

2.3 – Scale Factors
Stretching and Shrinking

Name _____ Hr_

The diagram shows a collection of mouths (rectangles) and noses (triangles) from the Wump family and from some impostors.

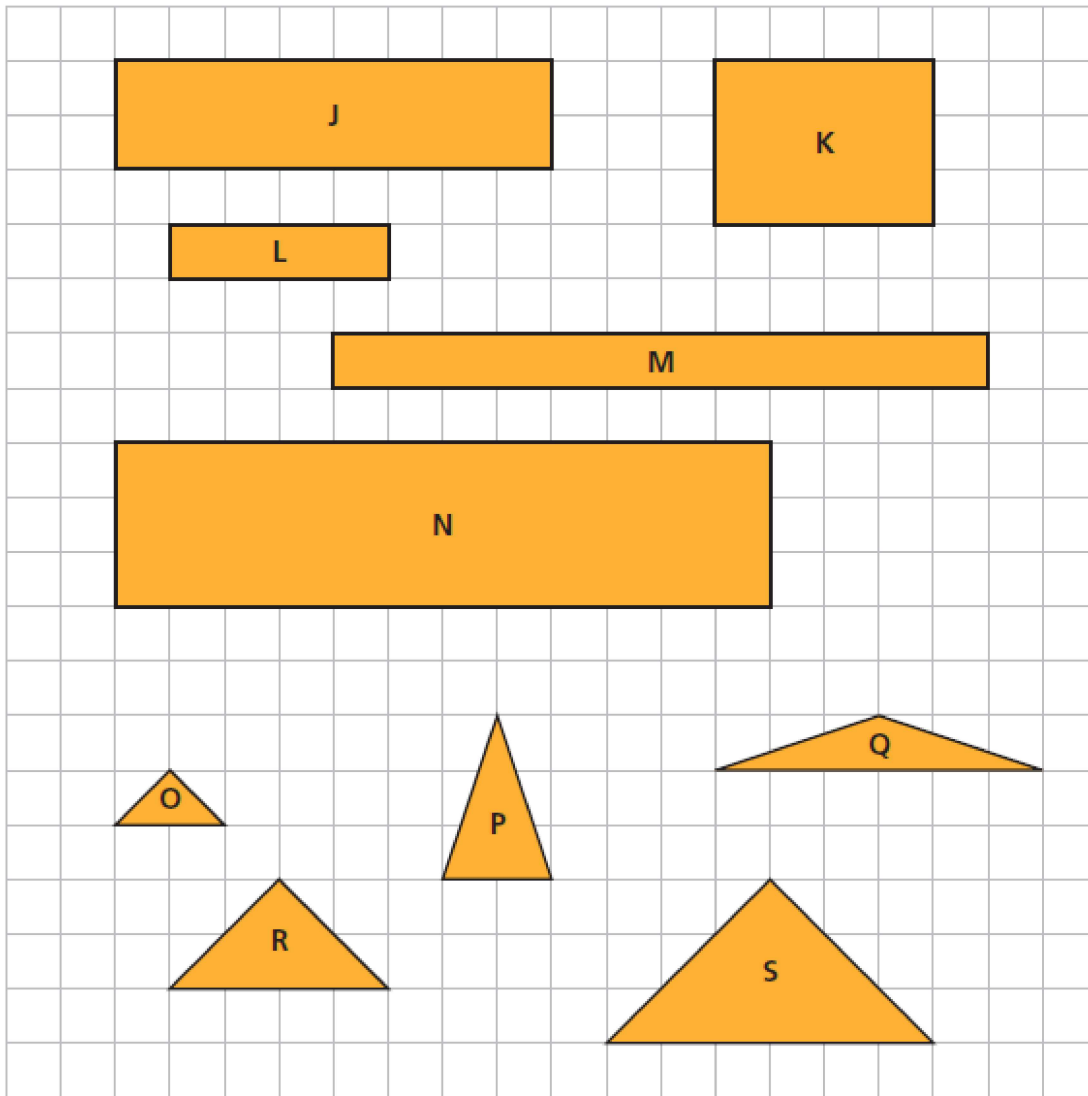


Figure A1. Accompanying resource page distributed by Ms. Pearson.

APPENDIX B

BELIEFS AND VALUES SURVEY - FALL

Please answer all of the following questions (17 total). Remember, your responses will not be shared with other students and will be anonymous for research.

For questions 1-11, circle the ONE number that best describes your beliefs about math.

1) How good are you in math?

1	2	3	4	5	6	7
Not at all good						Very good

2) If you were to list all the students in your class from the worst to the best in math, where would you put yourself?

1	2	3	4	5	6	7
One of the worst						One of the best

3) Some kids are better in one subject than in another. For example, you might be better in math than in reading. Compared to most of your other school subjects, how good are you in math?

1	2	3	4	5	6	7
A lot worse in math than in other subjects						A lot better in math than in other subjects

4) How well do you expect to do in math this year?

1	2	3	4	5	6	7
Not at all well						Very well

5) How good would you be at learning something new in math?

1	2	3	4	5	6	7
Not at all good						Very good

6) Some things that you learn in school help you do things better outside of class, that is, they are useful. For example, learning about plants in science might help you grow a garden. In general, how useful is what you learn in math?

1	2	3	4	5	6	7
Not at all useful						Very useful

7) Compared to most of your other activities, how useful is what you learn in math?

1	2	3	4	5	6	7
Not at all useful						Very useful

8) For you personally, being good in math is:

1	2	3	4	5	6	7
Not at all important						Very important

9) Compared to most of your other activities, how important is it to be good at math?

1	2	3	4	5	6	7
Not at all important						Very important

10) In general, I find working on math assignments:

1	2	3	4	5	6	7
Very boring						Very interesting – fun

11) How much do you like doing math?

1	2	3	4	5	6	7
Not at all						Very much

For questions 12 to 15, think about the statement and circle the ONE number that best represents your level of agreement.

12) No matter how much math ability you have now, you can always change it quite a bit.

1	2	3	4	5	6
Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly agree

13) You can learn new things, but you can't really change your basic math ability.

1	2	3	4	5	6
Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly agree

14) You have a certain amount of math ability, and you can't really do much to change it.

1	2	3	4	5	6
Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly agree

15) No matter who you are, you can change your math ability a lot.

1	2	3	4	5	6
Strongly disagree	Disagree	Mostly disagree	Mostly agree	Agree	Strongly agree

For 16 and 17, answer as completely as you can.

16) What are some things you're interested in, or that you like to do? These could be hobbies, favorite pastimes, or other things you like to do in or out of school.

17) Describe your favorite math lesson from last year. What did you like about it? Why?

APPENDIX C

OBSERVATION PROTOCOL FOR STUDENT ENGAGEMENT

Adapted from Helme and Clarke (2001) with reference to Nicol and Crespo (2005), Stipek et al. (1998), Brantlinger (2007), Fredericks et al. (2004)

Behaviors to capture and code in fieldnotes

Student behaviors characteristic of **cognitive engagement**, with description or examples*:

- Student contributes mathematical idea (e.g., posing conjectures, offering a solution strategy, making a generalization)
- Student(s) self-monitor while working on a task
- Student concentrates on work (resists distractions and interruptions)
- Student gestures while working or talking (externalizing their thought process, Helme & Clarke, 2001)
- Student poses question seeking information and/or feedback (e.g., how did you get negative ten?; is it okay if we make a table? Non-example would be, “how do you do this?” when student has put little effort into the task.)
- Student completes peer or teacher utterance (e.g., teacher says, “we know it’s linear because the rate of change is...” and student fills in “constant.”)
- Student gives directions or information about the task to a peer (e.g., we’re supposed to go through number five; I think we should graph first then find the equation)
- Student justifies an argument or explains procedure or reasoning (e.g., responds to teacher “why” or “how did you get that” question)
- Student shows reflective self-questioning (e.g., how did I get that?; I got 60, wait, what should the units be?)
- Student perseveres in the face of challenge (e.g., says, “I don’t get this” or, “this is too hard” but continues working on the task)
- Student seeks challenge (e.g., continues working on task after a solution is reached, trying something beyond what is asked for, generating an additional representation, etc.)

*Also indicate if these behaviors are related to *context* rather than mathematical content

Student behaviors characteristic of emotional engagement, with descriptions or examples:

- Student offers encouragement to a peer (e.g., we can do this!)
- Student(s) begin working on a task with confidence and/or enthusiasm (e.g., starting work right away, not waiting for teacher to visit table)
- Student makes a positive emotional statement about a task or the lesson (e.g., this is fun; this is interesting; wow, class really went fast today; I like this problem)
- Student(s) show visible excitement when working on or talking about the content through gesturing or tone of voice (e.g., animatedly trying to talk over one another during a discussion)

Real-time assessment of student engagement

For *most* students in the class, the best description of their cognitive engagement is:

1 – **disengaged** (sleeping, talking about topics not related to the mathematics, being disruptive, not working on task or visibly not paying attention to teacher)

2 – **somewhat engaged** (appear to be working on the task or paying attention to the discussion with some distraction, but not actively taking part in discussion)

3 – **engaged** (actively participating in class discussion, talking with peers about the mathematics task, generally “on task”)

4 – **elaborately engaged** (students are sharing ideas, justifying arguments, or explaining their reasoning with two or more consecutive sentences)

For most students in the class, the best description of their emotional engagement is:

1 – **active resistance (negative emotion)**

2 – **boredom**

3 – **neutral or interested**

4 – **eagerness, enthusiasm, excitement**

APPENDIX D

LESSON-SPECIFIC STUDENT SURVEY

Adapted from Cai & Merlino (2011)

I am interested in learning what you thought and how you felt about the lesson today. Please take a minute to think about the following questions and write how you truly feel. Your response is confidential, and there is no right or wrong answer!

1) Today’s math lesson felt like watching or participating in a sporting event such as _____ because _____

Example: In today’s math lesson, I felt like I do when I’m watching a sporting event like baseball, because I like baseball but there were many slow and boring parts.

2) Rate the **level of effort and thinking** you put into today’s lesson, where 1 means you weren’t really paying attention or trying in class, and a 4 means you thought hard about what you were learning and tried your best to do the work.

1	2	3	4
Low			High

3) Rate **how much you enjoyed** today’s lesson, where 1 means you hated the lesson, and a 4 means you thought the lesson was interesting and exciting.

1	2	3	4
Low			High

APPENDIX E

LESSON-SPECIFIC TEACHER SURVEY

Rate the level of effort the students seemed to put into today's lesson relative to the "average" lesson, where 1 means you think they weren't really paying attention or trying in class, and a 4 means they were thinking hard about what you were teaching and they were trying their best to do the work.

1
Low

2

3

4
High

Rate how much the students seemed to enjoy today's lesson relative to the "average" lesson, where 1 means they seemed to hate the lesson, and a 4 means they seemed interested and excited.

1
Low

2

3

4
High

APPENDIX F

FOCUS GROUP INTERVIEW PROTOCOL

We're going to talk a while about your lesson today. I understand it might seem strange to think and talk generally about today's class. Just try to remember what it was like to learn math today, and be honest! Anything you say here is confidential.

- 1) If a friend who is in the same class later in the day (or a parent, etc.) asked you what math class was like today, what would you tell him or her?

[Follow up on this question with the following, as appropriate: What would you tell them you learned? Was class pretty normal today, or particularly boring, interesting, etc.? Why?]

- 2) What (food, sporting event, movie) did you compare the lesson to?

[Follow up on this question with the following, as appropriate: What was it about the task [name the specific problem(s)] today that made you feel that way?]

- 3) What was your favorite part of class today? Least favorite? Why?

- 4) How beneficial (or useful) do you think the stuff you learned today will be *for you*, either in this class, future classes, or life outside of school? Why?

[Remind students about specific content from the lesson, as needed.]

- 5) What did you rate your effort for the day?

[Follow up on this question with the following, as appropriate: Do you mind telling us why you answered that way? Was there something about the problem(s) [name the specific problem(s)] today that affected how hard you worked?]

- 6) What did you rate your enjoyment for the day?

[Follow up on this question with the following, as appropriate: Do you mind telling us why you answered that way? Was there something about the problem(s) [name the specific problem(s)] today that affected how much you enjoyed class?]

Table F1

Summary of Lessons Preceding Interviews

Lesson	Lesson Content	Description of Context	Focus group attendance
Pine River 2	Interior and exterior angles	None	All present
Pine River 5	Subtracting positive and negative integers	Money contexts (spending and earning) were used in some problems	Felix absent
Pine River 7	Multiplication and division of integers	None	All present
Pine River 10	Making similar figures	“Wumps” characters-- identifying which figures are similar to Mug Wump and are in the Wump family, and which are impostors	All present
Pine River 14	Applying properties of similar shapes	Determining heights of tall objects (in this case, a clock tower) using shadows	All present
Southpoint 2	Scale factors	Continuing the Wumps context, analyzing the characters’ noses and mouths	Jacob did not participate
Southpoint 5	Comparing ratios	Julia and Mariah are making chocolate cookies for their fellow campers. They consider four different mixes; students need to determine which is the most “chocolatey”	All present
Southpoint 7	Finding rates	Sascha is going on a bike trip with three legs. Students are told how long each leg is and how many minutes it took to finish. They find and compare unit rates and think about how fast they would need to ride to race Sascha.	All present

Table F1 (cont'd)

Southpoint 10	Using the chip model for integer addition and subtraction	A few tasks in the homework reviewed use money contexts (spending, earning, owing money); student spontaneously references having a certain number of abstract "points"	All present
Southpoint 13	Operations on integers	One problem used temperature context; spontaneously used money as support in operating with decimals	All present

APPENDIX G

LESSON ENGAGEMENT CODEBOOK

Table G1

Lesson Engagement Codebook for Evidence of Student Engagement from Lesson Transcripts

Student behaviors characteristic of cognitive engagement , with description or examples	Examples from data
Student contributes mathematical idea (e.g., posing conjectures, offering a solution strategy, making a generalization)	McKenna raises hand and offers, “I got 105 degrees,” contradicting another student’s answer. T: So what did you get for the sum? McKenna: I got 525. (Site A, Observation 1)
Student(s) self-monitor while working on a task (e.g., “wait, that’s not right”; “I think that makes sense”; two or more students exchange papers to check own and/or others’ work)	Jacob: I said all the angle measures are the same, but—T: Which Hat are you talking about? Jacob: All but Hat 4. Most of them are the same. Actually, no, never mind, I messed up. (Site B, Observation 1) S4: Yeah, but there’s got to be three red chips though. Emily: This is like—I’ve got to think about it.
Student concentrates on work (resists distractions and interruptions)	This should be explicitly noted in the comments or transcript
Student gestures while working or talking (externalizing their thought process, Helme & Clarke, 2001)	This is should be explicitly noted in the comments or transcript.
Student poses question seeking information and/or feedback (e.g., how did you get negative ten?; is it okay if we make a table? Non-example would be, “how do you do this?” or “has anyone done A4 yet?” when student has put little effort into the task.)	Adelyn: I don’t understand how you pair [the hats] [...] So what do you say then, that they have the same angles. (Site B, Observation 1)
	NON-Examples: McKenna: I have a question on C. I don’t get it [...] Did anyone get A4 yet? I didn’t get it. (Site A, Observation 1)
	Asking (in whole class) to go over a homework problem, or general question about an assessment (e.g., can we use our notes on the exam?) Sophia to McKenna: What are you working on right now? (Site A, Observation 14)

Table G1 (cont'd)

<p>Student completes peer or teacher utterance or answers direct question from teacher (doesn't require explanation or elaboration) (e.g., teacher says, "we know it's linear because the rate of change is..." and student fills in "constant.")</p>	<p>T: What do you notice about which polygon has the smallest angle? McKenna: The triangle. (Site A, Observation 1)</p>
<p>Student gives directions or information about the task to a peer (e.g., we're supposed to go through number five; I think we should graph first then find the equation)</p>	<p>Elijah: You're trying to find if they're similar, they have the same general shape. [...] So you're seeing if going from Mug's hat to Hat 1, if they have the same angles. Compare the angles and side lengths. Compare each hat to Mug's hat. (Site B, Observation 1)</p>
	<p>NON-Examples: Jeff: I'm on A4 right now. (Site A, Observation 1)</p>
<p>Student justifies an argument or explains procedure or reasoning (e.g., responds to teacher "why" or "how did you get that" question)</p>	<p>T: Well the same, right? Why would they be the same? McKenna: Because the sun is shining on both of them at the same time. And so the shadows are going to be the same, since it's a similar shape. (Site A, Observation 14)</p>
<p>Student shows reflective self-questioning (e.g., how did I get that?; I got 60, wait, what should the units be?)</p>	<p>Drayton: A 25-foot shadow? [...] That's, like, bigger than this room! (Site A, Observation 14)</p>
<p>Student perseveres in the face of challenge (e.g., says, "I don't get this" or, "this is too hard" but continues working on the task)</p>	<p>Lilly: Ugh, this is so confusing...the last one should <i>not</i> be 1440! I'm so confused. [Continues to work with McKenna on the table.]</p>
<p>Student seeks challenge (e.g., continues working on task after a solution is reached, trying something beyond what is asked for, generating an additional representation, etc.)</p>	
<p>Student behaviors characteristic of emotional engagement, with descriptions or examples</p>	
<p>Student offers encouragement to a peer (e.g., we can do this!)</p>	<p>Jeff: See? [McKenna] did do it right! (Site A, Observation 9)</p>
<p>Student(s) begin working on a task with confidence and/or enthusiasm (e.g., starting work right away, not waiting for teacher to visit table)</p>	<p>This should be explicitly noted in the comments or transcript.</p>

Table G1 (cont'd)

<p>Student makes a positive emotional statement about a task or the lesson (e.g., this is fun; this is interesting; wow, class really went fast today; I like this problem)</p>	<p>Drayton: This is easy! Felix: I'm done, I'm done! (Site A, Observation 14)</p>
<p>Student(s) show visible excitement when working on or talking about the content through gesturing or tone of voice (e.g., animatedly trying to talk over one another during a discussion, raising or waving hand, showing surprise or agitation)</p>	<p>This should be explicitly noted in the comments or transcript.</p> <p>Ex: A student makes an excited statement about watching a launch video or cranes neck to see what's on the board.</p> <p>Emily: I didn't know you can do that! I would have thought you have to start with one color! (Site B, Observation 9)</p>

Notes

When there is an exchange between two people: Often, when two (or more) students interact or a teacher and student act, there are a short series of statements and questions in the event. I counted each of these “events” as single pieces of evidence of cognitive engagement. So, for example, a teacher asks a student a question, the student responds, the teacher asks a follow up question, the student responds—this counts as ONE example of the student explaining their reasoning or responding to the teacher’s question.

When this is unclear: If this is unclear, think about—is this student engaged *in this moment*? How do I know? Did the student just prepare a single answer to a teacher’s question, or a single question to ask someone? Or, do they *persist* in engaging—do they ask a relevant follow-up question or continue explaining an idea further, worthy of another count of engagement evidence?

When there is an exchange between two people involving different types of engagement: If an event such as the one just described starts with the student asking a question for information and/or feedback, the teacher responds and asks a question, the student responds—that could count as two separate pieces of evidence of engagement—asking the question, then responding appropriately to the teacher’s question.

When a student verbalizes thinking for no one in particular: When students are working individually “in parallel” and verbalizing thinking, this can count as explaining their procedure, self-monitoring, etc.—even if no one appears to be listening (consistent with Helme & Clarke, 2001).

When it's noted that a student raises their hand: If a student raises their hand *to offer response to teacher's question*, count as emotional engagement regardless of whether or not they are called on.

If multiple students raise hands to respond: If in one instance, multiple focus group students raise, hands, note names and count as one piece of evidence. If different students raise hands in response to different questions, count as different evidence of student engagement.

If multiple students respond in unison: Multiple FG students respond to the teacher or to each other in unison—this counts as one piece of evidence, but note both students' names because it can count for each student.

If it's not clear whether engagement is related to content or context: Only mark content or context if this is clear—for example, when students are persisting or concentrating/resisting distraction, it is not possible to clearly identify if they are focusing on content or context.

When students comment on something context-related: When students make comments on something context-related, it could be an example of self-monitoring or reflective self-questioning (see Drayton's example of this above) if it seems students are checking or making sense of their solution. If a student contributes to a discussion (e.g., completes a teacher utterance) on the context and it is closely linked to the mathematics in the task, also counts as CE. But if it's just a random comment, it might not count as engagement at all, or if it is an indication they're really "into" the task, it's likely emotional engagement.

When a student says something task-related (might only be context related) that's indicated in the fieldnotes with an explanation point: Mark as evidence of emotional engagement when it falls into the category of "positive emotional engagement" (as most research describes it—enthusiasm, excitement, confidence). Multiple students may make these "enthusiastic statements" within an interaction segment or conversation. Count each as a new count of emotional engagement.

When students exchange papers to check one's own or others' work: Mark as one count of evidence of cognitive engagement (self-monitoring). Though multiple students are involved, it is usually hard to discern if one student (and who) initiated.

When a student checks in with peers about status on a task WITH evidence they have been working on task: It can be ambiguous because the student's intent may be unclear. But can assume they want to know if they are on track either in terms of time or mathematically, so count as *self-monitoring*.

APPENDIX H

ENGAGEMENT ANALYSIS CHARTS FOR PINE RIVER: MRS. MEYER'S CLASS

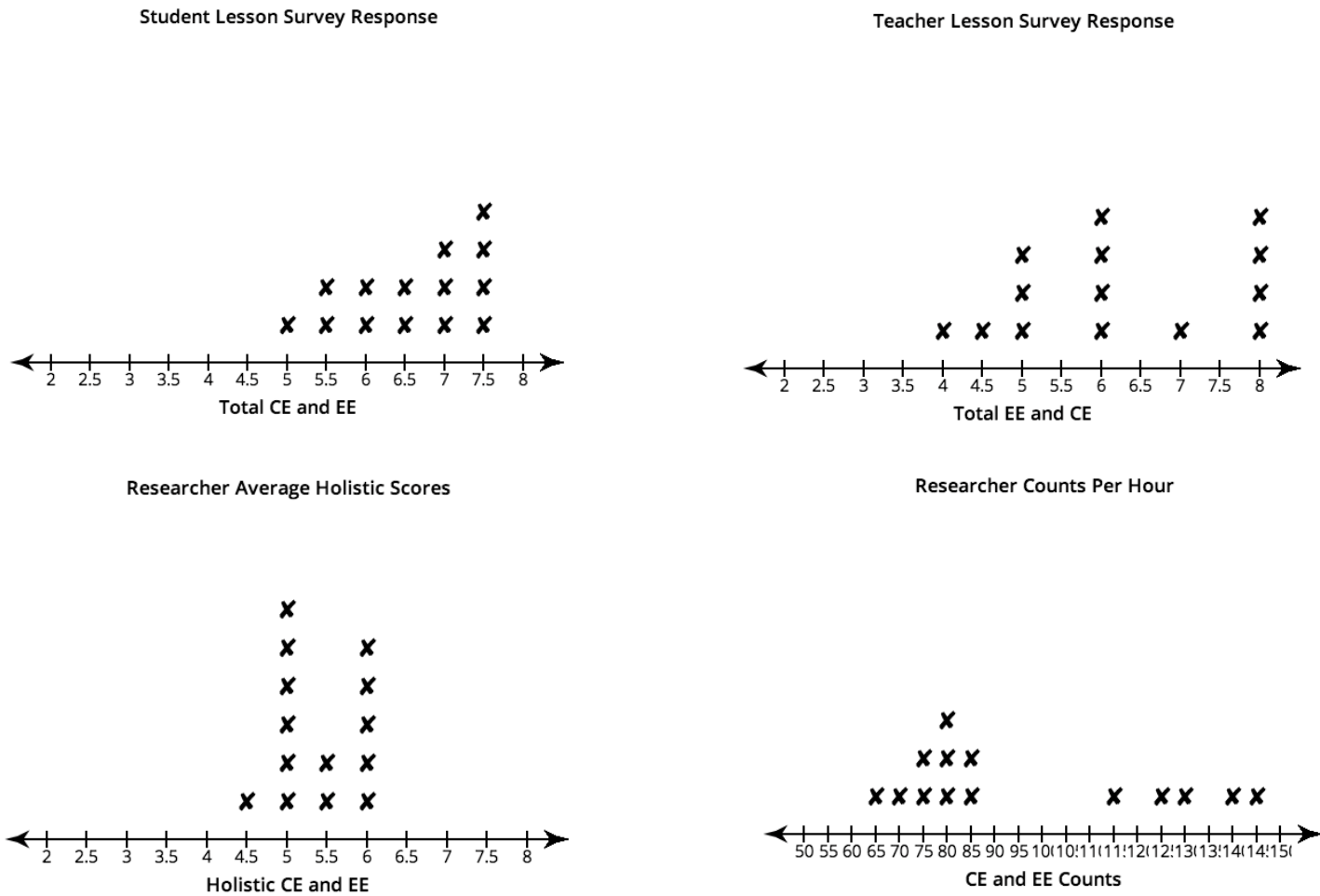


Figure H1. Dotplots of student and teacher engagement ratings over lessons at Pine River.

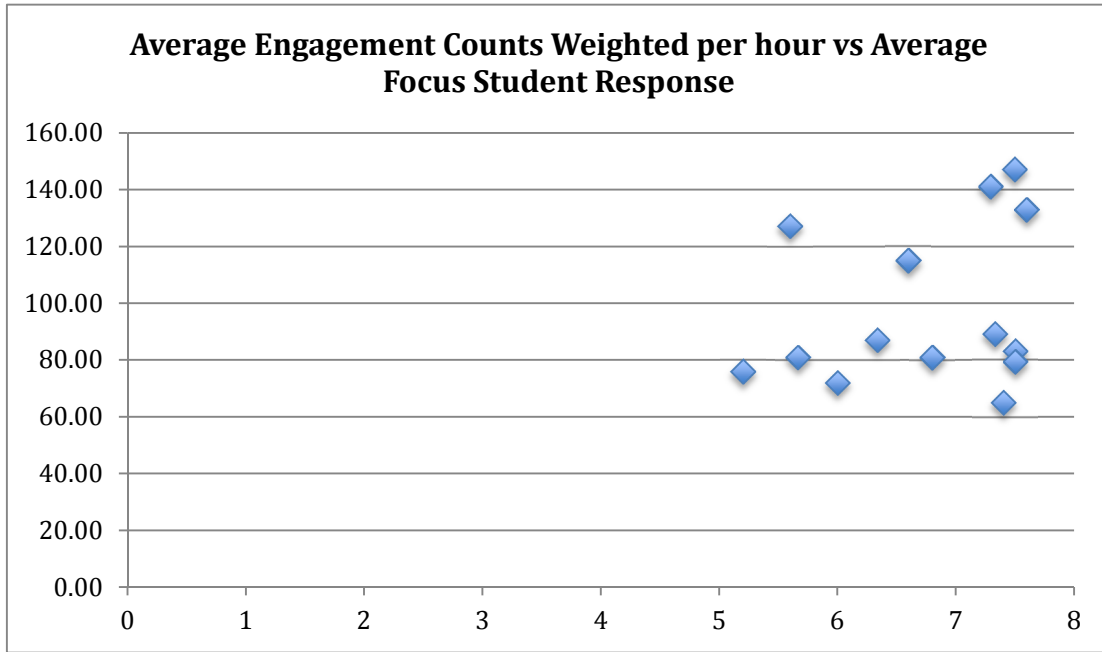


Figure H2. Scatterplot showing average weighted engagement counts per hour versus the average focus student engagement rating at Pine River

APPENDIX I

ENGAGEMENT ANALYSIS CHARTS FOR SOUTHPPOINT: MS. PEARSON'S CLASS

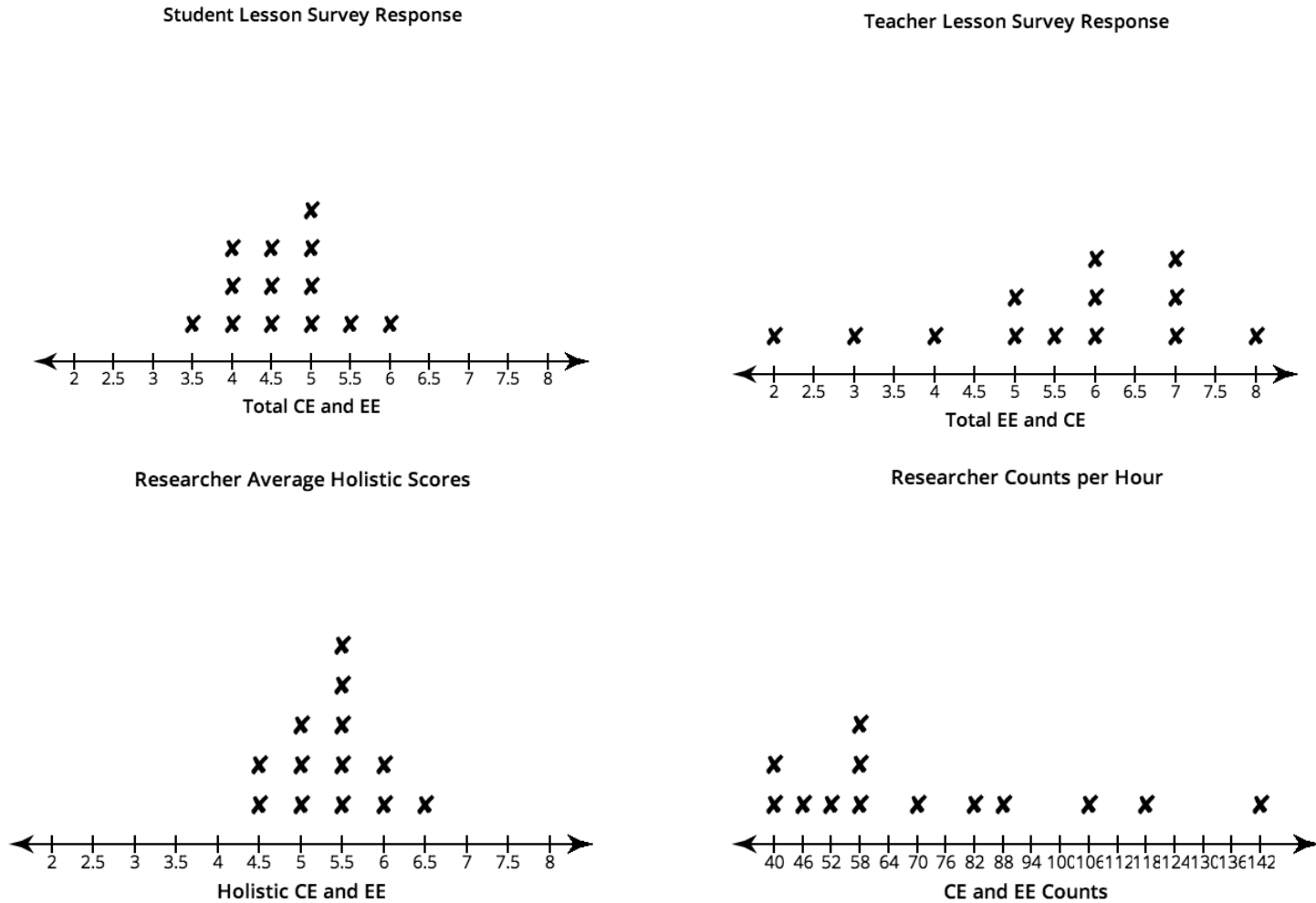


Figure 11: Dotplots of student and teacher engagement ratings over lessons at Southpoint.

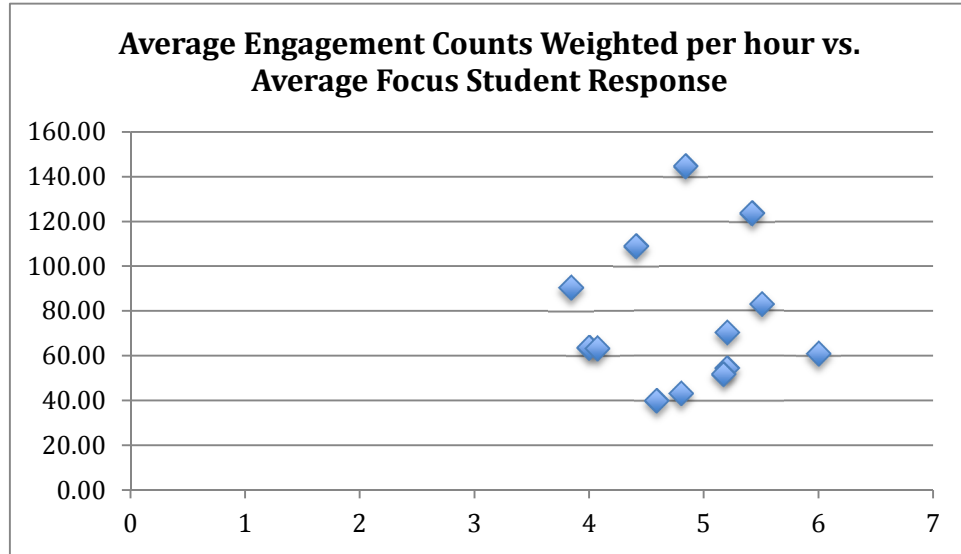


Figure 12: Scatterplot showing average weighted engagement counts per hour versus the average focus student engagement rating at Southpoint.

APPENDIX J

COMPARING AND SCALING 3.2 MODIFIED BY MS. PEARSON

3.2 – Finding Rates

Name _____ Hr__

Comparing and Scaling – Goal 8

Facilitator: Make sure everyone knows the instructions and that everyone does all parts of the problem. It will help to read all the directions first before beginning

Recorder/Reporter: Your group needs to organize a poster with all your results. Your poster needs to have everyone's work, be well organized, and use math tools, arrows, and/or colors to show your thinking.

Resource Manager: Manage materials needed. Make sure all questions are group questions! Don't let your group stay stuck – call me over!

Team Captain: Make sure everyone understands the solution to the problem. No talking outside your group!

Your group will work together to explore finding different unit rates. Answer the questions on your notepaper. You will need a copy of your own answers. At the end, you will create a poster.

Sascha cycled on a route with different kinds of conditions. Sometimes he went uphill; sometimes he went mostly downhill. Sometimes he was on flat ground. He stopped three times to record his time and distance for the section he just biked.

- Leg 1: 5 miles in 20 minutes
- Leg 2: 8 miles in 24 minutes
- Leg 3: 15 miles in 40 minutes

- A. What is the total time and distance Sascha biked?
- B. Find Sascha's rate in miles per hour for each part of the route.
- C. Explain mathematically on which leg of the trip do you think Sascha was cycling:
 - a. The fastest.
 - b. The slowest.
 - c. Uphill.
 - d. Downhill.
 - e. On flat ground.
- D. You can maintain a steady rate of 13 miles per hour on a bike. How much time will it take you to travel the same total **distance** Sascha traveled?
- E. Suppose you're going to race Sascha. What steady rate would you have to maintain on the bike to tie him? (Remember, "tie" means finish the same distance in the same amount of time. You will probably have to go a different rate than that in part D.)
- F. On a sheet of graph paper, create a graph that shows Sascha's time and total distance he biked. Time should go on the x-axis. Distance should go on the y-axis.

When EVERYONE is finished, organize your work for just parts A, B, C and F (if you get to it) into a large poster. Your poster should clearly communicate your solutions and justifications! Make connections between ideas, the shapes, and your justifications with color, arrows, or other tools. You may tape one person's graph on the page.

APPENDIX K

TABLE K1: SUMMARY OF OBSERVED LESSONS

Table K1

Summary of Observed Lessons

Pine River Middle School							
Lesson	Date	Main Task	Lesson Content	Learning Goal(s)	Placement in Unit	Description of Context	Other Notes on Lesson Activities
1	9/17/13	<i>Shapes and Designs</i> Investigation 2, Problem 1	Angle sums of regular polygons	Determining how to find the size of each angle and the sum of all angles in a regular polygon with n sides	In Investigation 1, students explored general properties of polygons, how to measure and estimate angles, and using information to draw uniquely-determined figures	None	
2	9/26/13	<i>Shapes and Designs</i> Investigation 2, Problem 4	Interior and exterior angles	Identify exterior angles and relate their measures and sum of their measures to the measures of interior angles	Students continue to analyze properties of polygons before learning to design polygons with certain properties in Investigation 3	None	
3	10/3/13	<i>Shapes and Designs</i> Investigation 3, Problems 2 and 3	Drawing triangles and quadrilaterals with certain combinations of angles and side lengths	Determining the smallest number of side lengths and angle measures that will tell how to draw an exact copy of any given triangle; determining what combinations of side lengths can make a quadrilateral and how many different shapes are possible with these combinations	These problems are near the end of the unit; students are synthesizing ideas about polygons and their side lengths and angle measures	Problem 3.2 asks students to determine the shortest test message possible to tell a friend how to draw a specific triangle; 3.3 is not contextual task	Mrs. Meyer started with a discussion summarizing Problem 3.2, leading to a mathematical argument between some students about the Angle-Angle-Side rule. Then transitioned to 3.3, using polystrips to investigate quadrilaterals

Table K1 (cont'd)

4	10/22/13	<i>Accentuate the Negative</i> Investigation 1, Problems 3 and 4	Using number lines and the chip model	Modeling number sentences with number lines and the chip model, and using these tools to generate number sentences	These lessons come early in the unit, after students have explored integers generally and have been introduced to the number line as a way to compare integers. The number line and chip model will be used throughout the unit to develop understanding of integer operations	Temperature and money contexts (earning and spending, being in the “red” or “black” were used in some problems involving integer operations	Mrs. Meyer orchestrated a summarizing discussion of 1.3, then students worked on 1.4, followed by a whole-class discussion of 1.4 part (a) only. Students were introduced to the chip model for operating with integers.
5	10/29/13	<i>Accentuate the Negative</i> Investigation 2, Problem 2	Subtracting positive and negative integers	Using the chip model and number lines to develop an algorithm for subtraction of integers	Students have begun to develop an algorithm for addition of integers, and will go on to relate the addition and subtraction algorithms and explore multiplication and division of integers	Money contexts (spending and earning) were used in some problems	
6	11/05/13	Graphing activity from <i>Accentuate the Negative</i> in CMP 2 nd edition, Investigation 2, Problem 5	Coordinate graphing in four quadrants	Identify coordinates of points and plot points in all four quadrants of the coordinate plane	This was a supplemental lesson to provide some students practice with positive and negative integers and graphing in all four quadrants between exploring addition and subtraction of integers and multiplication and division of integers	For challenge activity at end of lesson, some students graphed picture or figure to exchange with another student	Some students finished a quiz (including Sophia and McKenna). Other students worked on a graphing activity—organized in groups, but worked individually in parallel. Challenge/extension graphing activity available for students who finished before the end of the hour.

Table K1 (cont'd)

7	11/12/13	<i>Accentuate the Negative</i> Investigation 3, Problem 4	Multiplication and division of integers	Exploring patterns in the products and quotients of integers while playing the “Integer Product Game” in pairs	Students have generated algorithms multiplication and division of integers and are relating these operations before synthesizing across all four operations in Investigation 4	None	
8	11/21/13	<i>Stretching and Shrinking</i> Investigation 1, Problem 1	Mathematical similarity	Exploring what it means for two figures to be mathematically similar	This is the introductory lesson in the unit, providing an open-ended opportunity for students to explore the major mathematical ideas in the investigation and unit	There’s a contest in a middle school, and the Mystery Club is working together to figure out who the mystery teacher is from a photograph.	Students did not actually get into the problem as written in this lesson. Mrs. Meyer asked them to investigate the more open-ended introductory question in the text—finding the teacher’s height using any strategy.
9	12/04/13	<i>Stretching and Shrinking</i> Investigation 2, Problem 1	Making similar figures	Determining if two shapes are similar by looking at the rule for producing specific coordinates for the image	Students have explored what it means for figures to be similar, and have generated informal rules for similarity. This is the first lesson in the investigation in which students define scale factor and consider similarity in graphed images	Two contexts: a) Fictional students Zach and Marta designing a computer game, and b) the “Wumps”—identifying which figures are similar to Mug Wump and are in the Wump family, and which are impostors	Mrs. Meyer had differentiated plans in place. After awhile, struggling students receive a completed table so they can begin graphing.

Table K1 (cont'd)

10	12/05/13	<i>Stretching and Shrinking</i> Investigation 2, Problem 1	Making similar figures	Determining if two shapes are similar by looking at the rule for producing specific coordinates for the image	Students have explored what it means for figures to be similar, and have generated informal rules for similarity. This is the first lesson in the investigation in which students define scale factor and consider similarity in graphed images	Same context as lesson 9, but focused on identifying which figures are similar to Mug Wump and are in the Wump family, and which are impostors	Mrs. Meyer had differentiated plans in place. Students who finish receive more figures to graph.
11	12/19/13	Mathematics Assessment Project pilot Formative Assessment Lesson <i>Real-life Equations</i> ⁸	Interpreting real-life expressions and equations	Connecting algebraic expressions and equations to real-life situations, addressing misconceptions related to the meaning of variables in expressions and equations	This lesson was not part of their 7 th -grade curriculum sequence. It built on 6 th -grade content in <i>Variables and Patterns</i>	Students interpreted equations involving the number and price of eggs, apples, and bananas.	
12	1/09/14	<i>Stretching and Shrinking</i> Investigation 3, Problem 4	Finding lengths using similar triangles	Using similar triangles to find distances that are difficult to measure directly	Students should have a firm understanding of similarity and scale factor, and are now applying these concepts to solve contextual tasks involving missing measurements in shapes	Determining the distance across a river to build a boardwalk across	

⁸ Formative Assessment Lessons and more information about their development are available at <http://map.mathshell.org>, a project led by Mathematics Assessment Resource Service University of Nottingham and UC Berkeley.

Table K1 (cont'd)

13	1/15/14	<i>Stretching and Shrinking</i> Investigation 4, Problem 3	Applying properties of similar shapes	Using properties of similarity and given information about shapes to find unknown side lengths, perimeters, and areas	Students should have a firm understanding of similarity, scale factor, and ratio, and are now applying these concepts to solve contextual tasks involving missing measurements in shapes	None	Lesson began with going over Problem 4.2 and going over a Learning Check
14	1/16/14	<i>Stretching and Shrinking</i> Investigation 5, Problem 1 (CMP 2 nd edition)	Applying properties of similar shapes	Using properties of similarity and given information about objects to find heights that are difficult to measure directly	This lesson comes near the end of the unit. Students should have a firm understanding of similarity, scale factor, and ratio, and are now applying these concepts to solve contextual tasks involving missing measurements in shapes	Determining heights of tall objects (in this case, a clock tower) using shadows	
Southpoint							
Lesson	Date	Main Task	Lesson Content	Learning Goal(s)	Placement in Unit	Description of Context	Other Notes on Lesson Activities
1	9/19/13	<i>Stretching and Shrinking</i> Investigation 2, Problem 2	Changing a figure's size and location in the coordinate plane	Determining coordinate rules that produce similar figures and nonsimilar figures; using coordinate rules to predict side lengths in pairs of similar figures	Students have explored what it means for figures to be similar, and have generated informal rules for similarity. In this lesson, students continue to consider similarity in graphed images and coordinate rules	Continuing the Wumps context, analyzing characters' hats	Continued the lesson from the day before.

Table K1 (cont'd)

2	9/24/13	<i>Stretching and Shrinking</i> Investigation 2, Problem 3	Scale factors	Generalizing strategies for deciding if two figures are similar, finding and using scale factors	After exploring similarity in shapes and graphed images, students have a definition for similarity and scale factor and generalize these ideas to other shapes.	Continuing the Wumps context, analyzing the characters' noses and mouths	Ms. Pearson modified the task somewhat, making a task card with small group roles and a resource page consistent with Complex Instruction practices. Also, had students develop posters to present their work.
3	10/1/13	<i>Stretching and Shrinking</i> Investigation 4, Problem 1	Ratios within similar parallelograms	Exploring what information is provided by ratios of adjacent side lengths in rectangles and parallelograms; relating this information with similarity	Students should have a firm understanding of similarity and scale factor, and are now exploring the role ratios play in generating similar figures and solving problems involving similar shapes	Investigation begins with photo image being "dragged" to change the size and shape; Problem 1 is not contextual	
4	10/25/13	<i>Comparing and Scaling</i> Investigation 1, Problem 1	Analyzing comparison statements	Exploring what different comparisons of quantities tell about the relationship between the quantities	This is the introductory lesson in the unit, providing an open-ended opportunity for students to explore the major mathematical ideas in the investigation and unit	A soda company is using results from a taste test comparing their product with another in their ad. A copywriter suggested four comparison statements to use in the ad	Lesson started with students doing a short self-pre-assessment on the new learning objective and exchanging books, since this is a new unit.

Table K1 (cont'd)

5	10/31/13	<i>Comparing and Scaling</i> Investigation 2, Problem 1	Comparing ratios	Determining and analyzing different strategies to compare quantities for their accuracy and efficiency	Students used ratios, fractions, percents, and differences to compare quantities in the first Investigation; now they begin to analyze and choose appropriate strategies for solving different problems	Julia and Mariah are making chocolate cookies for their fellow campers. They consider four different mixes; students need to determine which is the most "chocolatey"	Ms. Pearson modified the task, making a task card with small group roles consistent with Complex Instruction practices. Also, had students develop posters to present their work and changed the context from determining the most "orangey" juice to the most "chocolatey" cookie.
6	11/7/13	Class goes over <i>Comparing and Scaling</i> Investigation 2 homework problems, then completes a "ticket out the door" assessment and begins answering the Mathematical Reflection questions for the Investigation	Comparing ratios, percents, and fractions	Review and assess student understanding of content in the Investigation	Students have developed strategies for selecting and using appropriate solution methods for comparing quantities and are reviewing this content before investigating rates and proportions	One homework task involved determining the most "appley" juice. In another, Duane and Miriam make pottery bowls; students need to determine who is faster. A third problem involves a party; students need to determine at which table someone can get the most pizza.	Ms. Pearson had been gone for a few days unexpectedly, so this lesson was mainly about reviewing problems students worked on in her absence and assessing their understanding of the Investigation.

Table K1 (cont'd)

7	11/14/13	<i>Comparing and Scaling</i> Investigation 3, Problem 2	Finding rates	Calculating and making sense of rates and the relationship between distance, rate, and time	Students have developed strategies for using ratios to compare quantities are now solving problems involving rate before working with proportions	Sascha is going on a bike trip with three legs. Students are told how long each leg is and how many minutes it took to finish. They find and compare unit rates and think about how fast they would need to ride to race Sascha.	Ms. Pearson modified the task somewhat, making a task card with small group roles consistent with Complex Instruction practices and adding parts to the problem. Also, had students develop posters to present their work.
8	11/26/13	<i>Comparing and Scaling</i> Investigation 4, Problem 3	Solving proportions	Developing general strategies for solving problems involving proportions	This is the final lesson in the unit; students are solidifying their understanding of proportions to solve different contextual problems	Multiple parts of problems had different contexts: estimating puffin populations, a traveling jet plane, Jack eating enchiladas at work and estimating his calories consumed, and a middle school population by grade compared with the numbers of students on student council.	Lesson started with going over Investigation 4 homework and Ms. Pearson introducing the essay prompts for an assignment due the following week. Then students were allowed to work individually on 4.3 or could choose to work with a partner.

Table K1 (cont'd)

9	12/10/13	<i>Accentuate the Negative</i> Investigation 1, Problem 4	Using the chip model	Using the chip model to represent number sentences with addition and subtraction of integers	This lesson comes early in the unit, after students have explored integers generally and have been introduced to the number line as a way to compare integers. The chip model will be used throughout the unit to develop understanding of integer operations	Temperature and money contexts (earning and spending, being in the “red” or “black” were used in some problems involving integer operations	Students mainly worked as a whole class as they are introduced to the chip model, but also spend several brief sessions in small groups to solve problems.
10	12/12/13	<i>Accentuate the Negative</i> Investigation 1, Problem 4; work on teacher-produced small group assignment containing homework problems from CMP	Using the chip model	Using the chip model to represent number sentences with addition and subtraction of integers	Students have been working with the chip model for two lessons; this was a formative assessment opportunity before using the chip model to develop algorithms for integer addition and subtraction	A few tasks in the homework reviewed use money contexts (spending, earning, owing money); student spontaneously references having a certain number of abstract “points”	The class reviewed 1.4 homework together, then students worked on teacher-produced small group assignment containing homework problems from Investigation 1
11	12/16/13	<i>Accentuate the Negative</i> Investigation 2, Problem 2	Subtracting positive and negative integers	Using the chip model and number lines to develop an algorithm for subtraction of integers	Students have begun to develop an algorithm for addition of integers, and will go on to relate the addition and subtraction algorithms and explore multiplication and division of integers	Spontaneous use of quarters to help add multiples of 0.25; forgiving debts and temperature change to make sense of subtracting negatives; money contexts (spending, earning, debt)	

Table K1 (cont'd)

12	1/10/14	<i>Accentuate the Negative</i> Investigation 3, Problem 3	Division of integers	Determining an algorithm for dividing integers and relating integer multiplication and division	This lesson focuses on the last operation—division—before synthesizing these ideas and moving toward properties of operations	None	Teacher generated an “investigation sheet” that mirrored the CMP problem with some modification—took out the one contextual part of the task (about a Number Relay) and added scaffolding for students to determine an algorithm for division
13	1/13/14	Review activity (<i>Accentuate the Negative</i>) with students responding to prompts individually on white boards	Operations on integers	Review properties of negative and positive numbers and practice adding, subtracting, multiplying, and dividing	Students have algorithms for all the integer operations and are reviewing to get reading for a Learning Check and the semester exam	One task used temperature context; spontaneously used money as support in operating with decimals	
14	01/14/14	Go over review sheets, do a “learning check” (i.e., quiz), begin working on exam review	Scale factor, ratio, rate, operations on integers	Review and assess student understanding of three units of content		One task used money contexts (spending, earning, owing money)	

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