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MAKING MEANING OF ALGEBRA 2 TEACHERS:
A CASE STUDY OF ONE SCHOOL

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF INSTRUCTIONAL LEADERSHIP AND ACADEMIC CURRICULUM

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This work is dedicated to the teachers whose daily practice formed the basis of this dissertation. I will forever be grateful that you allowed me to share in your professional life and learn from you. Your passion and dedication reaffirm my belief in the power and possibilities of mathematics education and increased my hope in the future of public education. Your students are truly blessed.

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Abstract

As the variety of curriculum materials available to teachers multiplies, understandings of the process by which mathematics teachers make meaning of curriculum materials must be revisited and revised. Rather than beginning with a single text that serves as a primary source of curriculum, mathematics teachers must interweave multiple curriculum materials, written by multiple sources for multiple purposes with multiple audiences in mind. This case study uses as social constructivist view to investigate the processes by which secondary mathematics teachers make meaning of curriculum. This process is examined using multiple lenses including transactional theory, metacognitive theory, and a critical perspective. In particular, this case study examined one professional learning community consisting of four mathematics educators and one special educator who taught Algebra 2 at a large suburban high school in a southern plains state who routinely made meanings from both familiar and unfamiliar curriculum materials during the 2016-2017 school year. Data collection included interviews, think-aloud sessions, observations of individual and collaborative planning session as well as lesson, and document analysis of the curriculum materials used by the participating teachers. Analysis of these data reveal that these teachers participate in a highly complex system of meaning-making best viewed as a transactional system consisting of teachers, students, curriculum materials, and local contexts which act on and through each of the other aspects.

Keywords: teacher meaning-making, curriculum materials, transactional system, curriculum enactment, mathematics, mathematics education

Chapter 1: Introduction

Textbooks have been, and continue to be, the primary curriculum materials used in mathematics classrooms (Ben-Peretz, 1990; Usiskin, 2010). Because of the primacy of the textbook in mathematics classrooms, when national reports, standardized assessments, and the growing prevalence of job sectors which relied on mathematical ability in the 1990s pointed to a need to improve school mathematics programs, one of the first efforts was the development of new curriculum materials (Fey, Hollenbeck, & Wray, 2010; Remillard, 2000; Reys, Reys, & Rubenstein, 2010). In response to the standards-based era in mathematics education, the National Science Foundation (NSF) funded several new curriculum series (Schoenfeld, 2004). As districts, schools, and teachers began to use newly developed curricula funded by the NSF, researchers began to study how mathematics teaching and learning were impacted by these new textbooks. The belief was that as teachers adopted textbooks which contained innovative ideas about mathematics teaching and learning, their practice would come to reflect these ideas. The NSF materials initially developed at the beginning of the standards-based curriculum era were expected to change teaching so that mathematics classrooms focused less on rote practice and algorithms, and more on conceptual understanding and problem solving (Stein & Kim, 2009).

However, results of studies on these curriculum materials have been discouraging. Some studies have focused on results of large scale standardized tests. These tests initially showed some improvements in mathematics, especially at the elementary level, but a long term analysis of the Long Term Trend National Assessment of Educational Progress show that by grade 12, students showed little to no

improvement between 1990 and 2007 (Kloosterman & Walcott, 2010). These studies demonstrated that standards-based curriculum did not significantly impact student achievement outcomes (Tarr et al., 2008). Instead, studies found that teachers resisted the curricula and student achievement did not noticeably rise (Kloosterman & Walcott, 2010; Remillard, 2000). While purposeful professional development did show positive effects in teachers' use of these materials, few teachers sufficiently engage in sustained professional development efforts focused on these curriculum materials (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Lee, Duncan, Yoon, Scarloss, & Shapley, 1991; Taylor, 2013).

These findings reflected those of similar studies conducted after the implementation of the 'new math' NSF funded materials of the 1950s and 60s; in both eras, reform was sought through newly-developed textbooks, but studies showed minimal improvement in student achievement after such textbooks were adopted. One of the original explanations for this lack of progress focused on teachers' abilities to implement the new concepts of teaching and learning used by the NSF materials (Stein & Kaufman, 2010). The materials created were "foreign in form and content" to most teachers who had experienced 'traditional' mathematics as a student (Remillard, 2005, pp. 211–212). In short, though new textbooks were adopted, they had little impact on the practices of teachers (Stein & Kaufman, 2010). Instead, the curriculum was most influenced by teachers' knowledge, beliefs and values (Remillard, 2000). After these studies, researchers concluded that too much emphasis had been placed on the role of curriculum materials, and not enough focus had been placed on the role of the teacher; as a result, the materials spoke directly to students, without considering the teacher as

an important audience of the materials (Remillard & Bryans, 2004). Teachers who used these materials, then, often misinterpreted their intent, ignored novel and unfamiliar content, or undermined the purpose of various aspects of these curriculum materials (Remillard, 2005). In other words, teachers largely resisted the change efforts that these materials represented; instead, most teachers used the materials in ways that matched the beliefs, values, goals, and knowledge they have formed before adopting the material (M. Brown, 2002).

Curriculum

The findings above clearly indicate that textbooks, or other written curriculum materials, do not solely determine the curriculum of a class or course. Instead, curriculum remains true to its Latin root 'currere', meaning to run (Mcknight, 1975; Pinar, 1975). Rather than simply a collection of topics or standards, curriculum includes the activities and experiences intended for and enacted with students (Remillard & Heck, 2014). It encompasses both a plan for learning experiences as well as the actual learning experiences. Curriculum, therefore, is a lived experience shared by teachers and students; teachers and students collaboratively 'run the course' even as they work together to define the course.

Curriculum is often envisioned in three phases; the written curriculum (as defined by textbook, curriculum standards and guides, and other written curriculum), the intended curriculum created by the teacher as they plan for classes, and the enacted curriculum experiences by students during class (Stein, Remillard, & Smith, 2007). This process, though often envisioned as temporal phases, is reflective and reiterative in nature. For example, teachers may use knowledge and beliefs formed when enacting

prior curriculum to develop the intended curriculum (Stein et al., 2007, p. 321). However, the specific means by which written curriculum is transformed into an intended and, ultimately, an enacted curriculum are still unclear. Indeed, "distinctions are infrequently made between the curriculum as outlined by the policy makers or curriculum designers and the curriculum interpreted or intended by the teacher." (Stein et al., 2007, p. 321). Understanding how written curriculum is transformed is crucial. Not only must we understand what processes are used, but which processes prove most feasible and effective, how written curriculum can be designed to support these processes, and how teacher education programs and professional development programs can be designed to support and further develop mathematics teachers' abilities to successfully transform curriculum to meet the needs of their students.

The importance of understanding the meaning-making of teachers has become even more critical because now, more than ever, teachers consult additional sources of curriculum materials beyond those adopted by their districts, including web based lesson resources and exchanges (Abramovich, 2013; Drijvers, 2015). There is significant evidence that the vast majority of teachers now select at least some of their curriculum materials themselves (Larson, 2016). In part, this may be due to an increase in guiding documents, like national or state standards, with which a specific textbook may not align (Usiskin, 2010). According to a study by the Education Development Center, almost half of teachers in a STEM content area routinely search for curriculum materials online (Abramovich, 2013). When teachers are given only broad standards or guidelines to follow rather than a specific text, they have more freedom to make curriculum choices (Ben-Peretz, 1990). The choice they make is necessarily dependent

on the meanings made from the written curriculum materials they consult. As teachers begin to consult more web based resources and other resources that may not have undergone disciplined publication and adoption protocols, the onus for ensuring the quality of curriculum materials shifts to individual teachers rather than publishing companies, states, and school districts. This shift adds yet another responsibility to the shoulders of teachers must contend with more administrative requirements and higher expectations using less time and resources than ever before, all while navigating a system of control implemented through a regimen of standardized tests and accountability measures in which they are given less autonomy and support. (Apple, 2004).

Meaning-Making

Although there has recently been significant research about the influences on teachers' use of curriculum materials, little research has investigated the specific processes teachers use to make meaning from materials or to choose from among materials (Remillard, 2009). Meaning making, or curriculum inquiry, is a distinct process from interpreting, adapting, and using materials; the purpose of meaning making is to determine "the potential of the curriculum materials so that these can be reconstructed for particular students and for specific classroom situations" (Ben-Peretz, 1990, p. xiv). In order to transform curriculum materials, teachers must be able to extract multiple potential meanings or themes from the curriculum materials (Ben-Peretz, 1990). Only once teachers perceive these meanings can they begin to interpret the meanings in light of their context and students (M. Brown, 2009). In other words, meaning making includes the activities through which the teacher makes sense of what

he or she is reading; their intended curriculum, then, depends upon the meaning or meanings evoked (Rosenblatt, 1978).

Remillard's case study of two teachers using a new curriculum text (2000) included a vignette that can serve as an illustration of the difference and relationship between meaning making and interpretation. Remillard studied how teachers learn from new textbooks. One of her teachers used a textbook that included problems of the day. The teacher voiced concerns over these problems, but, because she wanted to give the textbook a 'fair try', she implemented them in her classroom by giving a new problem to students each day, allowing students to work on the problem for five minutes, and then going over the solution, and thus "translating the problem into a computational algorithm" (Remillard, 2000, p. 336) . This is contrary to the purpose of such problems, which generally are meant to allow students to create their own solutions. However, she had not properly constructed the significance of these problems. In other words, her adaptations were not reflective of interpretations of the curriculum based on her students, the context in which she taught, or her beliefs and knowledge, but rather of a lack of meaning; she indicated that had not constructed a purpose for these problems, but had implemented them only to remain faithful to the curriculum materials. As students began to work with the problem, she was eventually able construct meaning in the problems where there had not been before, stating that "I see the reason for these things now" and changed the way she implemented the problems, allowing students more time and productive struggle (Remillard, 2000, pp. 336–337). Thus, this teacher changed her interpretation of the problems, and therefore the way in which they were

enacted in the classroom, only after she created new meaning of the purpose of the problems.

Purpose of the Study

This study investigates the meaning making process of Algebra 2 teachers at one high school. It investigates how the participating teachers make meaning both as they develop an intended curriculum and as they enact curriculum. The participants were purposefully selected for three reasons. First, the state in which they worked adopted new standards for Algebra 2 for the 2016-2017 school year, thus requiring the teachers to make meaning of these standards. Second, the teachers used a collaboratively constructed online curriculum library, which drew written curriculum materials from a variety of sources, as their primary source of written curriculum. Thus, they were routinely engaged in meaning making with diverse written materials. Third, the teachers planned to enact an entirely new unit of curriculum which some of them had constructed collaboratively in the summer before the 2016-2017 school year. Thus, there were significant opportunities to observe meaning making from both new and familiar curriculum materials.

The goal of the study was to illustrate the processes by which these teachers, collaboratively and individually, transformed their written curriculum materials into their enacted curriculum. By providing an account of their processes, I hope to support teacher educators and curriculum developers in their attempts to develop programs and curriculum materials that may facilitate these processes and help to ensure effective and engaging mathematical experiences for students. In particular, this study began by asking the following over-arching questions:

1. How do teachers make meaning from and transform written curriculum materials?
2. What processes do teachers use to make meaning from curriculum materials?
3. How does the context of a teacher's practice influence and/or constrain the teacher's meaning making process?

A thorough review of literature helped to focus this research on specific aspects of each question. In Chapter 2, I examine how the structure and content of curriculum is changed as teachers incorporate more diverse written materials, as well as how coherence and cohesiveness is addressed by teachers during this process. Chapter 3 utilizes reader response theory and metacognitive theory to examine the specific behaviors teachers utilize when making meaning from written curriculum materials. In Chapter 4, I look specifically at the role of context, in terms of physical space and professional place, in the meaning making of teachers. Finally, Chapter 5 relates the findings of all three chapters and discusses them in context of the current literature in the field.

Trustworthiness

Because qualitative studies do not follow the same type of strict procedural rules that quantitative studies often do, the trustworthiness of qualitative studies rests in the rigor and ethics used to carry out all aspects of the study, including conceptualization, data collection, data analysis, and the presentation of the findings (Merriam, 2009). This is especially true when utilizing a case study because of the sheer volume and variety of data collected; without the use of rigorous analysis, a researcher could selectively

choose data to illustrate any preconceived notions the researcher may have (Merriam, 2009). While this presents a challenge, a careful consideration of issues of trustworthiness and ethics allows for the construction of rigorous analytical procedures that safeguard against these dangers.

An essential component of a rigorous and ethical study is the explicit and purposeful consideration of issues of credibility, reliability, and transferability (Merriam, 2009). Credibility addresses the issue of how well findings align with the realities constructed by the participants (Merriam, 2009). Disciplined subjectivity is a key aspect of addressing issues of credibility (Merriam, 2009). It involves reflection and self-monitoring on the part of the researcher to ensure that the realities given in the findings reflect those of the participants, rather than the observer. It also requires that the researcher adequately engage in data collection; that is, the researcher must continue to collect data until they are saturated and no additional finding are emerging from the data (Merriam, 2009). The use of field notes and an audit trail aided in maintaining disciplined subjectivity as I interacted with participants throughout the Spring 2017 semester. The purpose of an audit trail is to account for how the study evolved; to detail my thoughts, questions, and decisions about the ideas and problems I confront while collecting and analyzing data (Merriam, 2009; Schwandt, 2015). Thus, an audit trial will allow others to follow the development of the findings.

Credibility must be addressed in the writing process itself; the resulting work demonstrates how carefully the research has been designed and carried out; thus, I strove to ensure that my writing was both rich and detailed (Rubin & Rubin, 2012). Thick description, that is, description which includes examinations of multiple variables

and their interactions in detailed, literal, and complete ways, is used throughout the findings sections (Merriam, 2009).

However, because the central characteristic of case study research is the unit of study rather than a particular method of analysis, triangulation is the most critically important aspect of ensuring disciplined subjectivity and trustworthiness of a case (Merriam, 2009). Triangulation ensures that the findings of the study "do not depend on mere intuition and good intention", but rather are derived through the cross comparison of multiple types of data (Stake, 1995, p. 107). Triangulation can involve "the use of multiple methods of data collection, multiple sources of data, multiple investigators, or multiple theories to confirm emerging findings." (Merriam, 2009, p. 216) This case not only employed multiple methods of data collection (interviews, observations, document analysis) and multiple sources of data (the various participants), but also employed multiple theoretical approaches: reader response theory, transactional theory and metacognitive theory. In this respect, the data were examined from both wide angle and focused lenses; transactional theory allowed me to consider the complete system in which the meaning making takes place, while reader response and metacognitive theory were used to look at the particulars of the processes used by the participating teachers.

Triangulation also helps to ensure consistency; that is, the extent to which results are consistent with the data collected (Merriam, 2009). By ensuring that findings align which each method of data collection, participant, and theory used to analyze the data, and rigorously investigating apparent discrepancies that may arise, the likelihood that the findings are consistent with all data is increased. An audit trail, as discussed above, helped ensure the consistency of the results.

It is also important to consider the transferability, or generalizability, of the findings of this study; that is, the ability to apply the findings to another case or instance of meaning making from curriculum materials (Merriam, 2009). It is my hope that the research design set forth here demonstrates the systematic and conscientious way in which the study was conceptualized and in which data was collected and analyzed. Presenting the findings in a way that allows readers to determine that the conclusions presented make sense will be equally important (Merriam, 2009). This required the use of rich, thick description of the findings as the description needed to illustrate the whole of the transactional system in which meaning is made by teachers. The complexity of such a system requires detailed and thorough discussion of each aspect of the systems and the ways in which those aspect interact. Only through the use of thick description can these complexities be illuminated (Merriam, 2009).

Position as Researcher

Qualitative research "inevitably includes and expresses the orientation, methods, values, traditions, and personal qualities of the researcher." (Wertz et al., 2011, p. 84). As an interpretivist researcher, a final measure used to account for the credibility and reliability of this study is for me to account for my own position as a researcher by examining my potential assumptions, biases, or other factors that may influence the way that I interpret the data in this study (Merriam, 2009).

I first became interested in teachers' meaning making of curriculum materials when I was employed as an instructional specialist in Maryland. One of my responsibilities in this role was to mentor new and struggling mathematics and science teachers. This often involved meeting with teachers as they planned for instruction.

Often, I found that, when we reviewed materials together, the meaning I constructed from the materials was often very different than that of my mentee; what I saw as engaging and meaningful conversation, they saw as a "fluffy waste of time", and where I saw busy work, they saw valuable practice of skills. During this study, it was important for me to suspend my own meanings of curriculum materials to let the participants' meanings emerge.

It was also extremely important for me to focus on and carefully consider issues of school culture. My teaching experience was exclusively on the east coast of the U.S. and in Canada. Oklahoma, as one might expect, has a distinctly different school culture than any district in which I have taught. Thus, when differences were noted, I carefully examined whether those differences resulted from something intrinsic to the teacher, or from the culture of the school, district, or community.

Finally, I am acutely aware that I had preexisting working relationships with each of the participants. The participants often invited me into conversations about curriculum materials. In the course of this study, I sought to maintain a stance as an "observer as participant"; that is, my participation with the teachers remained secondary to my role as an observer (Merriam, 2009, p. 124). As such, I viewed such invitations as opportunities to ask question which clarify the participants own thinking, rather than to insert my opinions. As this is a method I generally employ with student interns, both the former student interns and the former teacher mentors, appeared comfortable and familiar with this approach.

Significance of the Study

The increasing availability of mathematics curriculum materials online allows teachers to choose from a vast array of materials for any lesson they wish to teach. However, this greater freedom comes with greater peril as well; not only do teachers risk adapting materials that are of lower quality than those traditionally presented in textbooks, but by choosing materials from a wide range of sources, mathematics teachers risk the curriculum becoming fragmented and confusing, even if high qualities materials are utilized (Larson, 2016). Examining the ways in which teachers make meaning from curriculum materials is an essential first step in understanding the extent of these risks, the degree of teachers' understanding of these risks, and how teachers address these risks and how mathematics teaching and learning will evolve as sources of curriculum materials continue to expand.

Regardless of the sources of curriculum chosen by teachers, the teacher has a significant impact on the curriculum enacted in the classroom. The enacted curriculum is therefore limited by a teacher's ability to make meaning from curriculum materials; a teacher who makes only superficial meaning from curriculum materials will be unable to engage classes in deep or meaningful sense making or reasoning, a critical component of mathematics education (NCTM, 2000). Thus, mathematics curriculum is significantly shaped by the meaning making ability of mathematics teachers. Understanding the processes teachers use to make meaning, then, is essential for improving mathematics education and is currently a significant gap in the literature. This study represents an important first step in filling this gap.

Chapter 2: After the Textbook: Secondary Mathematics Teachers' Use of Curriculum Materials

The age of accountability and standards-based curriculum has prompted the creation of a myriad of new curriculum materials for secondary mathematics teachers. Shulman (1987) states that many studies on teachers' use of curriculum materials assume that teachers begin with a single text to consider. However, this is becoming less common because of increasing availability of other sources of curriculum materials. Historically, these materials have been largely created by commercial publishers, but curriculum materials also include materials designed by software and hardware manufactures, such as Texas Instruments, individual teachers, and non-profit organizations (Usiskin, 2010). In addition, local, state, and national governmental agencies are increasingly developing standards and policies meant to serve a guides to teachers (Ben-Peretz, 1990). Finally, curriculum materials for secondary mathematics are increasingly becoming available online (Abramovich, 2013).

Secondary mathematics teachers are beginning to turn to the textbook less often and draw on a variety of other publications because of this increased access to alternate curriculum materials (Ben-Peretz, 1990; Chval, Chavez, Reys, & Tarr, 2009). As the popularity of textbooks decreases, the prevalence and popularity of web based lesson resources and exchanges are increasing (Abramovich, 2013; Drijvers, 2015). The vast majority of teachers now select at least some of their curriculum materials themselves (Larson, 2016). According to a study by the Education Development Center, almost half of teachers in STEM content areas routinely search for curriculum materials online

(Abramovich, 2013). The availability of extensive online resources has fundamentally changed the ways in which teachers interact with curriculum materials. Before this technology, the quality of curriculum resources teachers encountered was controlled by publishing companies and district supervisors; the availability of internet-based teacher resources eliminates these control factors (Abramovich, 2013). Further, because these materials were created by different people with different views of teaching and learning as well as different motivations and goals, these materials may not be well-aligned, if at all, with each other or with guiding documents, (Usiskin, 2010).

When teachers are given only broad standards or guidelines to follow rather than a specific text, they have more freedom to make curriculum choices (Ben-Peretz, 1990). In their daily practices, teachers must contend with making meaning from these disparate sources in order to construct their intended curriculum, yet the lack of alignment and the sheer amount of content discussed in these curriculum materials is a source of concern for teachers (Fey et al., 2010). Disparate and misaligned curriculum materials increase the chance that curriculum coherence is lost as teachers adapt materials from a wide variety of sources and as students move between teachers who utilize different curriculum materials (Larson, 2016). That is, by using multiple sources created for multiple purposes by multiple people, teachers risk failing to create a curriculum that develops "important mathematics along coherent learning progressions" (NCTM, 2014). Understanding how teachers interact with this multitude of curriculum materials is thus of vital importance.

Although there has recently been significant research about the influences on teachers' use of curriculum materials, little study has been conducted on how teachers

make decisions about what curriculum materials to use. This case study investigates attempts to address this gap by studying a team of teachers that have consciously moved away from using a textbook as the primary source of curriculum and has, instead, organically created their own curriculum from a diverse array of resources. This study seeks to understand three essential questions. First, how does the structure and content of curriculum change as teachers utilize a wider variety of materials? Second, how do teachers integrate diverse curriculum materials into their curriculum? Third, how the teachers ensure coherence and cohesiveness; that is, how do teachers ensure that they present a curriculum that makes sense to students and is well integrated? To that end, a review of the literature about curriculum materials and models of curriculum use will be discussed. Then, findings will illustrate the structure of the curriculum developed by the participating algebra 2 teachers, and how teachers use and interact with the curriculum. The finding will demonstrate that teachers' use of curriculum is structured but nonlinear, that students and context play important roles in the use of the curriculum, and that the participating teachers attend to questions of coherence and curriculum primarily by relying on the curriculum structure presented in the previously used textbook as well as collaborative meaning making of curriculum materials.

Curriculum Materials

Curriculum materials are resources that inspire, guide, and organize teachers' efforts in teaching. These resources may include: syllabi; district, state, or national standards or guidelines or policies; teacher guides or handouts; worksheets; video or audio resources; academic, scientific, or literary works; or curriculum packages which offer teachers a self-referencing collection of such sources. In other words, curriculum

materials include any resource used by teachers in their daily practice (Ben-Peretz, 1990). These materials, even traditional textbooks, are rarely field-tested before publication (Usiskin, 2010). Thus "teachers are often asked to teach using materials that no one has tested, following guidelines that reflect dreams more than reality" (Usiskin, 2010, p. 36).

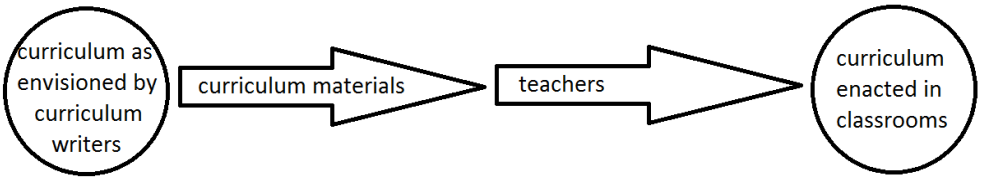
The study of teachers' relationships with curriculum materials is still in its infancy and continues to lack a firm theoretical base on which to build (Remillard, 2009; Remillard, Herbel-Eisenmann, & Lloyd, 2009), yet several frameworks for understanding this relationship have been proposed. These frameworks attempt to answer important questions about who decides what curriculum is or should be, and what factors influence the curriculum. One of the key issues is whether authority over the curriculum rests with designers of curriculum materials or teachers. Curriculum designers and teachers themselves disagree over where this authority should rest (Ben-Peretz, 1990). Though researchers, teachers, and curriculum designers can subscribe to any number of theories, there are two predominant categories into which the theories fall: fidelity of implementation and adaptive implementation

Fidelity of Implementation

The most traditional framework defines the written curriculum, in most cases a textbook, as the authority of curriculum. The aim of teachers is to implement the curriculum with fidelity; that is, the way in which the designers of the curriculum envisioned it being used (Ben-Peretz, 1990). Proponents of this view believe that curriculum should be "homogenized and standardized" (Ben-Peretz, 1990, p. 26).

Successful use of curriculum materials is use that is entirely aligned with the intent of the curriculum designers (Remillard, 2005).

Figure 1. Fidelity of Implementation Model

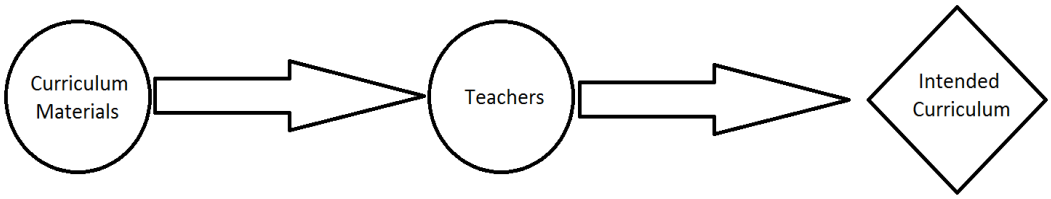


Many of the curriculum materials designed in the new math era reflected this theory of curriculum authority; efforts were made to create "teacher-proof" materials that insisted upon strict adherence by controlling not only the content but also the sequencing, pacing, emphasis, and instructional strategies used in classrooms (M. Brown, 2002, p. 4; Remillard, 2005, p. 215). This view implies that curriculum materials have the ability to 'transmit' not just concepts, but also practices to teachers and students (M. Brown, 2002). Complete fidelity, it was argued, could be reached given ideal conditions (Remillard, 2005). Therefore, changes in curriculum materials were not simply one means, but the only means of curriculum reform. Faith in curriculum materials as a means of enacting change remained the predominant view in mathematics education for most of the history of the field (Larson, 2009; McClain, Zhao, Visnovska, & Bowen, 2009). But research conducted during the 1990s in classrooms which had adopted standards-based NSF funded curriculum materials demonstrates that even in the most controlled environments, teachers retained at least some degree of freedom to determine the content, learning activities, and emphasis of the curriculum in their classrooms (Chval et al., 2009). Faced with this empirical evidence, curriculum developers and researchers began to reconceptualize the relationship between curriculum materials and teachers.

Adaptive Implementation

A second framework, generally referred to as adaptive implementation, addresses many of the failings of the fidelity of implementation framework. This model contends that the curriculum represented by curriculum materials can and should be adapted by teachers to meet the needs of their students and the local context (Ben-Peretz, 1990; M. Brown, 2002). In an adaptive model of teaching, teaching is seen as a design process in which teachers "perceive and interpret" curriculum materials in order to use them as they design curriculum (M. Brown, 2009, p. 18). Brown suggests that teachers' use of curriculum materials can be characterized on a spectrum. Teachers on one end of the spectrum use curriculum materials to offload curriculum decisions. That is, they tend to implement the curriculum represented in their curriculum materials literally. At the other end of the spectrum, teachers improvise curriculum with very little reliance on curriculum materials. In the middle, teachers adapt some elements of the curriculum materials. Brown contends that teachers may move along this spectrum within a given lesson, using some portions of the curriculum materials with fidelity while ignoring others in order to improvise their own curriculum (M. Brown, 2009). Thus, this model views teachers as having both agency and authority over the curriculum, while curriculum materials serve as stimuli for their endeavors (Ben-Peretz, 1990; Remillard, 2005).

Figure 2. Adaptive Implementation Model



The adaptive theory of curriculum better aligns with the nature and philosophy of the standards-based curriculum materials in mathematics. These materials stress the importance of allowing students to create their own strategies for solving problems and of having students communicate their mathematical thinking to others (Trafton, Reys, & Wasman, 2001). The materials recast the role of the teacher as that of a facilitator who responds to students' thinking and work and guides them towards new insights. Such instructional methods cannot be scripted, as teachers must respond to students in the moment (McClain et al., 2009; Remillard, 2000). Because if this, even when using the most scripted curriculum programs, teachers cannot be expected to reach full fidelity to curriculum materials. Thus, materials alone cannot shape curriculum; the authority to do so must lie with the teacher (Remillard, 2000).

Even when using the same curriculum materials, different teachers will implement different curricula in their classrooms (Thompson & Senk, 2010). Thus, textbooks and other curriculum materials are not authoritative sources of curriculum. Instead, they are tools; material objects used by teachers to accomplish specific goals they have for their classrooms (M. Brown, 2002). Likewise, teachers take on a new role of a designer of the intended curriculum, rather than a conduit for the written curriculum (Lloyd, Remillard, & Herbel-Eisenmann, 2009). In this way, the curriculum design process can be seen as a two phase process: the development of the written curriculum by curriculum writers, and the construction of the intended curriculum

through the alterations and adaptations teachers make to the written curriculum (Ben-Peretz, 1990; Remillard, 2005). To understand how intended curriculum is constructed, we must not only examine curriculum materials, but the ways in which teachers interact with or use those materials (M. Brown, 2009; Remillard, 2015).

There is much about teachers' use of curriculum materials we do not yet know. We know that teachers' work with curriculum materials has a profound impact on the curriculum (Ben-Peretz, 1990), but we know little of specific processes teachers use in their interactions with curriculum materials (Remillard, 2005, 2009). We know that teachers' use of materials are influenced by their knowledge and beliefs (M. Brown, 2009). We also know that teachers are able to make decisions about what materials to read and what not to read (Remillard, 2005). However, we know very little about how teachers select from among the curriculum materials available to them. We also know relatively little either about what teachers know about the various methods of teaching the content of their classes, or how they evaluate the overall quality when comparing different curriculum materials (Shulman, 1986).

Methodology

This study used an interpretive instrumental case study method to investigate how a group of five secondary mathematics teachers at a large suburban high school in a southern plains state created a cohesive and coherent curriculum from diverse curriculum materials in order to "illustrate, support, or challenge" the current models of teachers use of curriculum materials (Merriam, 2009, 28). The participants, the only Algebra 2 teachers at their school, worked collaboratively to make decisions about the Algebra 2 curriculum in their school. These participants, four math educators and one

special educator, were purposely chosen because five years ago, the Algebra 2 teachers at the school, as a collaborative team, made a choice not to rely on the district-provided textbook as their primary source of curriculum and instead build their own curriculum material library. In the intervening five years, despite changes in members of the team, a complete set of curriculum materials for the course had been gathered and organized.

For the 2016-2017 school year, their state adopted new standards for mathematics. In the summer before the school year, three of the five participants attended a two-day professional development workshop focused on the new standards that I helped their district curriculum supervisor develop and facilitate. In addition, during the same summer, three of the teachers also participated in a week long professional development workshop focused on the use of guided inquiry in secondary school settings. During this workshop, the participating teachers created a new unit of curriculum materials focused on sequences and series, which utilized guided inquiry methods. Together, the new standards and new unit created a unique opportunity to study how this group of teachers evaluated and incorporated new curriculum materials into their existing self-created curriculum. Specifically, this study sought to address the following questions:

1. How did the curriculum change since the Algebra 2 teachers began to create their own curriculum?
2. What strategies and processes, if any, do the participating teachers use to ensure coherence and cohesiveness when using multiple sources of curriculum materials?
3. How do participating teachers make decisions about what materials to use?

These questions seek to "*understand* how people make sense of their lives and experiences" from the perspective of the participating teachers (Merriam, 2009, pp. 23–24). Therefore, a case study methodology was used. This case is bounded by both time a place in that it looks specifically at the meaning making of Algebra 2 teachers at a particular school during the 2016-2017 school year, which presented multiple opportunities to observe these teachers incorporating the new state standards and other new curriculum materials.

Data were collected through interviews, observations, and document analysis. These data were analyzed using an interpretive perspective that seeks to understand how each participant interacted with the currently developed curriculum as well as with new curriculum materials, conscious that the process of each teacher depended upon the specific context in which each participant practices (Merriam, 2009).

Setting and Participants

Because the goals of this study include understanding how teachers addressed issues of coherence and cohesiveness, it is important to also understand the context in which the participating teachers worked, both in terms of their physical environment and background in education (Yin, 2011). The school in which they teach is in a suburban university town in a southern plains state. The high school has a history of excellence in mathematics teachers; multiple teachers in the mathematics department have received district, state, and national recognition for their teaching. The student body, approximately two thousand students, is largely white, with significant Hispanic, Black, and Native American Populations (Oklahoma Office of Educational Quality and Accountability, 2015). Though the average household income is significantly above

state averages, almost half of the students are eligible for free and reduced meals and poverty and unemployment rates are consistent with state averages (Oklahoma Office of Educational Quality and Accountability, 2015). Thus, there is a fair amount of income inequality among the students at the school.

Table 1. Certification, Education, and Experience of Participating Teachers

Pseudonym	Certifications	Degree(s)	Previous Years of Teaching Experience
Jennifer	Traditional Certification Secondary Mathematics	B.A. Math Education	11
Jessica	Alternative Certification Secondary Mathematics	B.A. Mathematics M.A. Mathematics	8
Sarah	Alternative Certification Special Education	B.A. Psychology M.A. Special Education	5
Amanda	Traditional Certification Secondary Mathematics	B.A. Math Education*	2
Emily	Traditional Certification Secondary Mathematics	B.A. Math Education	0

**Amanda began a M.A. in Mathematics Education in the summer of 2016.*

Each of the participants taught multiple sections of Algebra 2, as well as sections of other courses such as geometry, math analysis, and Advanced Placement calculus. Emily, a first-year teacher, taught two sections, while the other three mathematics educators taught four sections. Sarah, the special educator on the team, cotaught two sections of Algebra 2 with Jennifer, as well as Algebra 2 Applications, a course designed to support special needs students in Algebra 2. Algebra 2 is the highest-level mathematics course students must complete to graduate. As such, all students in the high school take Algebra 2 and classes may have students of multiple ages, grade levels, and previous experiences in mathematics.

I came to know Jennifer, Jessica, Amanda, and Emily through my work as a field supervisor for student interns; Jennifer and Jessica were mentor teachers to students and Amanda and Emily were former supervisees. Sarah and Emily both began working at the high school in the 2016-2017 school year, when the study was conducted. Each teacher expressed the desire to continuously innovate in their classrooms. These teachers work closely with each other when planning for their Algebra 2 classes. Their expressed desire to innovate and their culture of working and planning together meant that these teachers engaged in developing and evaluating their current curriculum on a regular basis. Thus, there were significant opportunities to observe their interactions with various curriculum materials.

Data Collection

Qualitative research depends on the use of multiple sources of data so that the situation under investigation can be viewed from multiple perspectives (Yin, 2011). As such, this case study used interviews, think-aloud sessions, observations, and document analysis. Three forty- to sixty-minute semi-structured interviews were conducted with each participant over the course of two months. The first interview focused on the participating teachers' beliefs, knowledge, and values about mathematics, teaching, and learning as well as their educational and teaching experiences. The second interviewfocused specifically on their understanding of and experiences with the curriculum they used in Algebra 2. Finally, the third interview focused on what teachers valued in curriculum materials and how they made decisions about which curriculum materials to use. The semi-structured nature of these interviews allowed informal follow-up questions to be asked when warranted (Merriam, 2009).

During the interview process, all participants discussed a shared Google drive folder which they reported contained all the curriculum materials used for Algebra 2. After obtaining permission from the participating teachers to access this Google drive, the documents were analyzed in three respects. The overall structure of the Google Drive was analyzed for coherence and cohesiveness. Individual curriculum documents were also analyzed both to determine, when possible, the source of the curriculum material, as well as to determine how the curriculum materials differ from the curriculum contained in the state's edition of Glencoe McGraw-Hill's Algebra 2, the textbook previously used by the participants' school (Carter, Cuevas, Day, Malloy, Casey, 2011). It is important to note that only the two most experienced teachers, Jennifer and Jessica, have been teaching Algebra 2 for the full five years in which the Algebra 2 Google drive has been developed. In addition, because of the organic nature of the curriculum, changes in and additions to the curriculum materials were made throughout the course of the study.

Participants were observed as they reviewed curriculum materials for use in their Algebra 2 classes. Notes made by the teachers on or about the curriculum material were also collected when appropriate and non-disruptive to the teachers' practices. During the study, the five participants met as a group to plan for Algebra 2 on three separate occasions. These planning sessions were also observed. Field notes were taken during both individual and collective observations.

The participants were also observed as they enacted the lessons they planned. The purpose of observations was to examine aspects that would otherwise be overlooked by participants and record these aspects without engaging in interpretation

(Merriam, 2009; Schwandt, 2015; Stake, 1995). Discrepancies between the written curriculum plan and the observed lesson were then discussed with participants in informal interviews following the lessons. Each participant was observed on six separate occasions. For the first three observations, each teacher was observed throughout the day, both as they planned and as they enacted lessons to multiple sections of Algebra 2. The purpose of these observations was to focus on the elements that were consistent for each section in which the lesson was enacted, as well as the discrepancies between different sections. For the final three observations, each of the five teachers were observed enacting a lesson based on the same curriculum materials to more directly observe differences in the enacted curriculum of the participants.

Finally, each participant engaged in three "think-aloud" sessions. During these sessions, participants were asked to think aloud as they reviewed curriculum materials; the spoken thoughts were then coded as an additional source of data (Bannert & Mengelkamp, 2008, p. 43). These sessions engaged teachers in sharing what they were thinking, doing, or feeling as they made meaning from curriculum materials. After they had fully reviewed the curriculum material, they were asked to share their thinking about specific portions of the curriculum materials to draw out further insights. This structure gave insight into both the meaning making teachers naturally engage in when reviewing curriculum materials, and the meanings they can make when prompted.

Three lessons were supplied for use during think-aloud sessions. Each of them broadly addressed rational functions. This content was chosen because the curriculum created by the teachers included a chapter on rational functions, which was the first chapter observed for this study. The think-aloud sessions all took place within a month

after the completion of the chapter so that the material contained in the chapter was fresh in the minds of the participating teachers.

The first lesson supplied, entitled *Light it Up!* is from NCTM's Illuminations website, which aims to increase "access to quality standards-based resources for teaching and learning mathematics" (NCTM, n.d.). The lesson centers on a cooperative learning activity embedded in a real world context that scaffolds students through the development of rational function models by having students explore relationships between problem contexts, equations, and graphs (J. Nelson, n.d.). In addition, the lesson plan provided significant support to teachers in the form of suggested questions to ask students, indications of when to pause for whole class discussion, and potential modifications directly with the text of the lesson plan.

The second lesson supplied, entitled "Introduction to Rational Functions*"* was drawn from a teacher's edition of a textbook entitled *Discovering Advanced Algebra: An Investigative Approach* (Murdock, Kamischke, & Kamischke, 2010), with which some of the participating teachers were slightly familiar, as they have drawn material from it for use in their classes. The aim of the publisher is to allow students to "concretely explore interesting problems and generalize concepts… to form a deep and conceptual understanding of advanced algebra topics." (Murdock et al., 2010, p. v). This lesson also provided some teacher support in the form of potential questions and modifications as well as alerts to potential challenges in the margins of the text.

The final supplied lesson was taken from the state's edition of Glencoe McGraw-Hill's Algebra 2, the primary text used in the school before teachers created their own curriculum (Carter, Cuevas, Day, Malloy, Casey, 2011). The textbook is a

more traditional textbook; its stated aim is to backmap the full high school program, in order to ensure the program is "well articulated in their scope and sequence, ensuring that the content in each program provides a solid foundation for moving forward." (McGraw Hill, n.d.). For this lesson, only the student version of the lesson was supplied. Thus, the lesson provided no teacher support.

While all the data collected provided valuable insights into the participating teachers' understandings of curriculum and curriculum materials, the primary focus in this study was the analysis of the Google drive curriculum materials. This analysis allowed the changes in the *written* curriculum to be studied, the sources of materials to be identified, and illustrated the specific structures used by the participants to ensure coherence and cohesiveness. Interviews, observations, and think-alouds provided insight into when, why, and how the curriculum was structured or changed in specific ways.

Data Analysis

Each of the interviews and think-aloud sessions were audio recorded and transcribed verbatim. Field notes were taken during class observations and individual and collaborative planning sessions. Researcher notes were taken as documents from the Google drive were analyzed in comparison to the previously used textbook. Each resulting set of data was then subjected to coding and theming using a constant comparison method to systematically identify themes within the data as they emerge. Originally a method used in grounded theory, the constant comparison method requires data analysis to begin when the first set of data is collected (Glaser & Strauss, 1967) while remaining open to any possible answer to the research questions future data may

contain (Merriam, 2009). Accordingly, open coding began with transcripts of the interviews, which were conducted in the late fall 2016 semester. This was followed by analysis comparing the contents of the Google drive used by the teachers and the previously used textbook. Finally, data collected in observations and think-alouds were analyzed as they were conducted in the spring 2017 semester. After reviewing and creating open codes for all for the data, axial coding was used to form categories of data that answered specific research questions (Merriam, 2009). Axial coding allowed the data from different sets to be compared and, ultimately, findings to emerge.

Findings

Each of the participating teachers identified the shared Google drive as their primary source of curriculum materials. However, each participant had their own ideas about how to use materials from the drive, when and how to add to or change the materials to the drive, and how to ensure that they deliver a coherent and cohesive curriculum. Despite these differences, the collaborative use of the Google drive allowed for participants to exchange ideas while maintaining autonomy. Both the organization and structure of the Google drive allow for effective collaborative efforts and individual instructional decision-making.

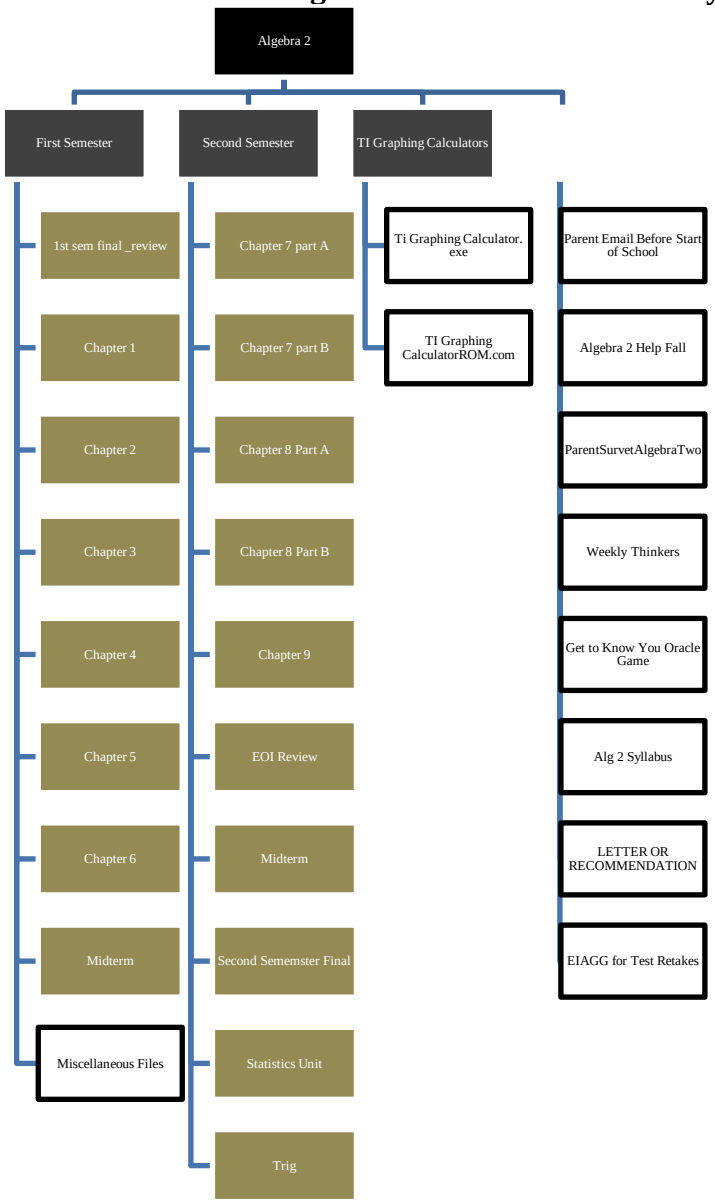
Structure of the Google Drive Curriculum Library

In many respects, the Google drive shared by the participating teachers acts as an online curriculum library. However, the Google drive provided more structure than most online lesson plan depositories. There are several layers of subfolders in the drive, as shown in Figure 3 below. At the top layer, the drive contains three subfolders and several individual documents. The main subfolders are entitled Semester 1 and

Semester 2, which reflects the districtwide structure of the school calendar; the expectation is that students are given an examination at the end of each semester. Though these are generally referred to as final examinations, most teachers and students maintain the same schedule throughout both semesters; only in rare cases are students' schedules altered mid-year. Thus, teachers and students alike view courses as year-long experiences.

In addition to the semester folders, a third folder, entitled TI graphing calculators, contains executable programs that allow teacher to display TI graphing calculator interfaces on the Interwrite™ interactive white boards that are in each of their classrooms. Finally, the individual documents contained in the highest level of the Google Drive curriculum library are used by the teachers either at the beginning of the school year, like a letter the teachers send to parents and a schedule of regularly scheduled help session that is distributed to students, or throughout the year, like the "weekly thinkers", which contains non-routine problems given to students each week.

Figure 3. Overall Structure of the Google Drive Curriculum Library



Semester Folders

The structure of the curriculum, and its relation to the previously used textbook, begins to unfold within the two folders labelled “Semester 1” and “Semester 2”. Both are similarly structured, with each chapter of the curriculum stored in a separate subfolder. All of the six units in semester one, and five of the seven units in semester two, have titles that refer to the previously used textbook. The remaining two units,

entitled “statistics unit” and “trig” diverge from the previously used textbook in important ways.

The textbook addressed content that is currently organized in the statistics unit throughout multiple chapters of the book, culminating in Chapter 12, which is entitled “Probability and Statistics” and includes content that goes beyond the demands of either the state’s old or new standards (Carter, Cuevas, Day, Malloy, Casey, 2011). However, both the old state standards and new state standards isolate these topics into a separate strand of the standards; the old state standards referred to these topics as “Data Analysis, Probability and Statistics” while the new state standards have a separate strand for “Data and Probability” (Oklahoma State Department of Education, 2009, 2016). The content of the “statistics unit” folder pulls together lessons that address the objectives contains in the related strands of the state standard, whether they be from Chapter 12 or earlier chapters. This content is also removed from the earlier chapters. Jennifer, who has the most experience teaching Algebra 2, explained that, even before the creation of the Google drive curriculum, the Algebra 2 teachers felt the need to bring the various data and statistics topics presented through the book together in a cohesive unit both so that it was all presented together and so that it addressed only the content that related to the state standards. Yet, when matrices were introduced into the curriculum, the teachers made a different decision; according to Jennifer,

> we went further into matrices than we had to, as far as the new [state] standards. Just because they only wanted us to add subtract and multiply by a scalar, and we were like, we can do more with this. And so, we did Cramer’s rule, so they can see systems, multiplication of matrices, and a two by two inverse. We took it a little further.

The additional topics listed by Jennifer match exactly the sections of the previously used textbook.

Trigonometry, on the other hand, has never been part of Algebra 2 standards for the state; however, both the old and new state standards include right triangle trigonometry as part of the Geometry Standards. The Algebra 2 teachers saw this as a challenge for students in their district, who typically take Geometry before Algebra 2, and a course entitled Math Analysis in the year after Algebra 2. Jennifer explained

> They see it in geometry, and then they jump to math analysis and they need trig and radians and we kind of felt like that would be a good end of the year unit to bring back the old, kind of introduce the new… it seems to be helping math analysis fit more time into solving a trig equation, trig identities, and graphing trig functions. It gives them more time for that.

In addition, Jessica explained that, due to required end of the year standardized exams, in previous years, there was about a month of instructional time after the required exams, when students needed to know the full algebra 2 curriculum, but before the end of the year. Thus, it seemed a natural fit to develop a unit for this time that could be used to prepare students for the next course.

Curriculum Unit Folders

Each unit, with few exceptions, is divided into six subfolders: notes, activities, worksheets, goal quizzes, tests and quizzes, and answer keys. The notes and activities folders contain the written curriculum used in the teachers' daily lives. The worksheets, goal quizzes, test and quizzes, and answer key folder contain the materials used for homework, tests, and quizzes. The separate folders for "goal quizzes" and "tests and quizzes" reflect a notable change in teachers' use of assessment since the Google drive folder was created. The tests and quizzes folder contains the quizzes used in Algebra 2 at the time the Google drive was created. Goal quizzes began to be used at Amanda's

urging when she joined the Algebra 2 team in the 2014-2015 school year. Goal quizzes had been used by her mentor teacher during her student teaching the year before. Their purpose is to give students instant feedback on their progress throughout the chapter. For each chapter, there is only a single goal quiz; however, there are multiple versions of the goal quiz, which contain the same question structures but with different numerical values used. Each goal quiz has exactly four questions (See Appendix B for an example). Students earn seven out of ten points by correctly solving one question, eight of ten points if they correctly solve two, and so on. The teachers review each goal quiz immediately after students take it to give students feedback on their progress in the chapter. Typically, the first version of the goal quiz is administered about halfway through a unit, and then different versions are administered every three to five days. Only the highest score a student earns on the goal quiz is recorded in the gradebook. While this represents a marked change in the teachers' approach to assessment, the questions on the goal quiz align well with the questions on the previously administered quizzes.

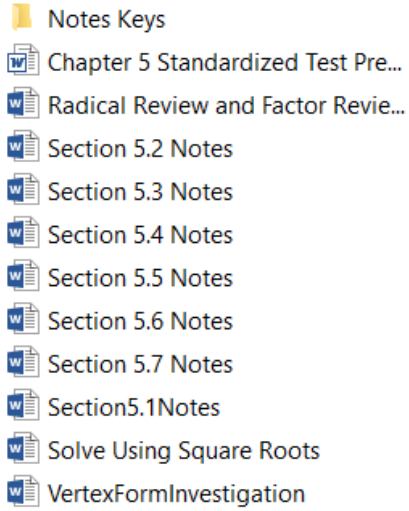
While it is impossible to tell how the contents of the tests, worksheets, and answer keys have changed through the development of the Google drive, as teachers routinely write over old files as updates are made, by comparing the notes and activities folders to the content of the previously used textbook, I was able to analyze how students' instructional experiences have changed since the teachers made the decision to

no longer use the textbook as their primary source of curriculum. Thus, the rest of this section is devoted to analyzing the contents of the notes and activities folders.

Notes Folders

Every unit folder contains a notes subfolder. The notes folder contains the documents that relay what the participating teachers believe is the essential knowledge of each unit. The documents are constructed so that each document serves as the backbone of one day of curriculum. These documents largely still follow the structure and ordering of the previously used textbook; in fact, the title of most documents retain the section number of the corresponding textbook sections, just as chapter titles reflect the structure of the textbook. For example, the content of the notes folder for chapter five, which is representative of the notes folders for all units, is compared to the sections of the corresponding chapter five from the textbook in figure 4.

Figure 4. The Files in Unit 5 of the Google Drive Curriculum Library and the Sections of Chapter 5 in the Previously Used Textbook

	5-1 Graphic Quadratic Functions 5-2 Solving Quadratic Equations by Graphing 5-3 Solving Quadratic Equations by Factoring 5-4 Complex Numbers 5-5 Completing the Square 5-6 The Quadratic Formula and the Discriminant 5-7 Transformations with Quadratic Functions 5-8 Quadratic Inequalities

Note that the two sets of documents do not correspond exactly. Based on state standards, the teacher removed 5.8 from the curriculum entirely. Further, there are documents in the curriculum library that to not correspond to a section of the textbook. These documents are obvious in that their names do not refer to textbook sections. Instead, they were created by the teachers to address specific issues. For example, Jessica reported that she created "VertexFormInvestigation" to allow students to investigate how different coefficients and constants transform the graph of a quadratic function, rather than presenting transformations as a list of rules, which she felt was important because chapter five is the first chapter in which students are asked to transform the graphs of functions. The documents "Solving Using Square Roots" and "Radical Review and Factor Review", on the other hand, were perceived by the participating teachers as addressing gaps in student understanding of radicals while "Chapter 5 Standardized Test Prep" was created by Jessica in response to administrative pressure to engage students in test preparation. These documents can be found in Appendix B.

All of the other files contained in the "Notes" folder for chapter five, as shown in figure 4, retain titles derived from the textbook. This is typical of all the units. Sometimes, sections from the textbook have been divided into multiple documents to maintain a one-document-per-day structure. When this has occurred, the title reflects such division by using the notation "Part A" and "Part B". Even when a file is meant to reflect an entire section of the textbook, the files are not mirrors of the textbook

sections, but rather pared down documents which provide only that information the participating teachers perceive as essential for the chapter.

The structure of almost all the textbook's sections follow a specific format. The sections open with a "Why?"; a brief description of an application of the mathematics contained in the section meant to motivate students. It then presents the first key concept for the section, usually as a definition, property, or theorem, followed by several examples which apply the concept. It proceeds through the other key concepts in a similar fashion, and ends with an extensive problem set meant to be used for independent practice. In the margins, real world applications or study tips are often included. However, none of the notes files for any chapter retained all of these elements. For example, an analysis of the elements kept, changed, removed, and added from each section of Chapter 7 is shown in Table 2.

Note that the vast majority of the content has been altered in some way; very little has been kept as it originally appeared in the textbook. Much of this was eliminated to reduce the notes to that which the participating teachers felt was absolutely necessary. In doing so, some of nuances of the content has been lost. For example, the notes for 7.4 do not discuss the necessity of using absolute vales when finding even roots of variable expressions. In fact, the notes for this section only address finding roots of numbers and monomials, while the textbooks address roots of binomials and polynomials as well. Both Amanda and Emily were observed enacting the curriculum from this lesson; neither included such a discussion in their classes.

When Jessica reviewed a different lesson from the previously used textbook for a think-aloud session, a similar loss of understanding was revealed. In Section 9.1,

students are introduced to rational functions, asked to perform basic operations on rational functions and identify the domain and range of the result. When presenting the rules for dividing rational expressions, the textbook states that “For all rational expressions a/b and c/d with $b \neq 0$, $c \neq 0$, $d \neq 0$” the quotient of a/b and c/d is equal to ad/bc (Carter, Cuevas, Day, Malloy, Casey, 2011, p. 555). This statement did not align with Jessica’s understanding: “they put that b cannot be zero, c cannot be zero, d cannot

Table 2. Analysis of Changes to Chapter 7

Section	Kept	Removed	Changed	Added
7.1 Part A: Operations		Why? Getting Ready Foldable Study Organizer All examples Tabular and graphical examples		Brief description of operations on functions All examples
7.1 Part B: Compositions		Definition of composition Examples of discreet function composition	Application of composition	Family Tree Bell work M&M Composition Optional Example 3
7.2: Inverse Functions and Relations	Definition of inverse Functions Property of inverses Discussion of verifying inverses	Why? Geometric explanation of example using three points Extension: Graphing functions and inverses (points and functions)	Example of verifying inverses (positive result) Examples of verifying inverses (negative result changed to positive result)	Graphical Bell work
7.3: Square root functions and inequalities	Summary of transformations of square root functions. Examples of graphing square roots with transformations and using the graph to find domain	Why? Definition of radical function	All examples	Bell work (review of operations and composition) ACT prep question Plotting table of values to make parent function Graphing calculator examples Parent function of cube root
7.4: nth roots		Why? Definition of nth root Definitions of radicand, radical , index, principal root Chart summarizing differences between even some odd roots when the radicand is greater than, less than, or equal to zero Discussion of need for absolute values around roots of variables Graphing n-the root functions	All examples	Examples of finding roots of numbers (no variables
7.5 Operations with radical expressions		Simplifying Expressions with the product property Quotient property of radicals Concept summary	Examples of adding and subtracting radicals, multiplying radials using the distributive property and using conjugates to rationalize the denominator	Examples of adding and subtracting radicals, multiplying radials using the distributive property and using conjugates to rationalize the denominator
7.6 Rational Exponents		Application Concept summary of simplifying rational exponents	Definition of b^(1/n) and b^(x/y) as a roots (eliminated b<0 and even n) All examples	
7.7 Solving radical Equations and Inequalities	Solving radical equations procedure Examples	Why? Standardized test prep Inequalities Using graphing calculators to solve		Additional Examples

be zero, but b and c are the only ones that are in the bottom." After contemplating this statement for several moments, Jessica continued to review the lesson without coming to a resolution on this discrepancy. Thus, not only are Jessica's students not being engaged in examining why the textbook statement is correct because of the "pared down" nature of the notes, but Jessica has either lost this understanding of rational functions herself, or never developed this understanding in her own education. In either case, this leaves Jessica's students without the opportunity to develop a complete understanding of the topic.

What has been kept from the textbook is the overall organization of each section. The key content of each section is still, most often, presented in the same order as in the textbook. In addition, when the teachers do present formal definitions, theorems, or rules, they are almost universally stated exactly as they are in the textbooks. Examples, on the other hand, even when retained, are much more likely to have been altered. Most of the examples in the notes documents are easily recognizable as textbook examples, though often with numbers changed. Most times, teachers believe these changes were made to make arithmetic easier, to highlight a particular issue with a specific type of problem, or to better align the example with state standards. However, their explanations do not always bear out. For example, Jennifer asserted that one example from the textbooks, in which students must compose two functions in order to show that they are not inverses, was changed so that the two functions given were inverses because the state standards required that students "verify" two functions were inverses using compositions, rather than "determine". In reality, neither the old nor the new state standards contain this language. The previous standards simply state that

students will “find and graph the inverse of a function, if it exists” while the new standards state that students will “combine functions by composition and recognize that $g(x)=f^{-1}(x)$, the inverse function of f(x), if and only if $f(g(x))=g(f(x))=x$.” (Oklahoma State Department of Education, 2009, 2016). In other words, the old standard did not require students to even verify two functions were inverses using compositions, while the new standard require that students not just verify, but determine if two functions are inverses.

Activities

While the documents contained within the “Notes” folder of each chapter clearly derive from the textbook, the activities clearly do not. Instead, the activities folders in each chapter represent a collection of instructional activities that have been gathered from a variety of different resources. Table 3 lists the most common types of instructional activities in the activities folder. Together, the activities given in Table 3 comprise just under 90% of the total number of activities stored in the Google drive.

Almost half of the activities stored in the Google drive folders were generated by the participating teachers or former Algebra 2 team members. Some of these, like fifteen of the sixteen applied problem sets, are drawn from multiple textbooks and resources; Jennifer and Jessica report having gathered the best applied questions from a number of sources, including several textbooks, to create these files, as they felt no one source had consistently quality applied questions covering the given context.

Table 3. Counts of Most Common Types of Activities

Type of Activity	Count
Matching Game	19
Applied Problem Sets	16
Scavenger Hunts	12
Investigations	12
Pass the Problem	11
Board Games	11
Riddles and Puzzles	7
Station Activities	6
Non- Routine Problems	5
Cups activities	5
Simulations	4
Discovery Activities	4
Pattern Activities	3
Jigsaw Activities	3
Mazes	3
Art Integration Projects	3
Peer Review Activities	3

Other teacher-generated activates are directly inspired by activities drawn from other sources. For example, Jessica first became aware of "cups activities" through her participation in a state sponsored professional development program. During these activities, students are then placed in small groups in which each member is given a specific job. The job of one team member, called the "traveler" is to pick a question from one of the cups to bring back to the group. The "recorder" then records the number of the problem on a worksheet or paper, and the group works together to determine a solution. A "summarizer" records the thoughts of their group members and the steps they take as they go. If the group is unable to solve the problem, the "questioner" can ask the teacher a question, but is expected to be able to explain what the group has done and why they are having difficulty. Once the group finds a solution, the recorder copies it onto the worksheet or into their notebook, and the traveler retrieves another question.

The purpose of the cups activity is to engage students in collaborative communication while solving the problems. While the original cups activity presented at the professional development which Jessica attended is included in the activities, there are also four other versions of this activity that Jessica generated for use in various chapters after she experienced success with the original activity. Likewise, the majority of matching games were created by Jennifer after experiencing success while implementing a matching game she found online.

I was able to determine the source for approximately two thirds of the activities not generated by the teachers at the school. The sources of these activities include online lesson depositories, both free and for profit, textbooks, professional development experiences (including Amanda's Master's program), practitioner journals, media outlets, and mathematics education organizations, as Table 4 shows.

Table 4. Identified Sources of Activities

Source of Activities	**Percentage of Activities**
For-Profit Teacher Resources Depositories	37%
Textbooks	22%
Professional development experiences	12%
Free Teacher Resources Depositories	11%
Practitioner Journals	8%
Media Outlets	4%
Math Education Organizational website	2%
Other	4%

While not every textbook used as a source was able to be identified, two textbooks were prominent sources: *Discovering Advanced Algebra: An Investigative Approach* and *Functions and Change: A Modeling Approach to College Algebra* (Crauder, Evans, & Noell, 2010; Murdock et al., 2010). Likewise, the participating teachers did not always recall from which professional development they received

particular materials. However, two professional development experiences seem to have served as sources for multiple activities: the Oklahoma Geometry and Algebra Project, a state sponsored summer workshop, and workshops provided by the K20 Center, an educational outreach organization at the University of Oklahoma. All other sources of activities were accessed online.

Teachers' Use of the Curriculum Library

Just as the sources of curriculum within the Google drive are varied, teachers' use of the curriculum materials are also varied. All the participating teachers agree that the materials contained in the notes subfolders of the Google drive constitute the mandatory curriculum in Algebra 2. However, the teachers disagree on how closely these files relate to the previously used textbook. Jennifer and Jessica both claim that the use of the notes assures that everyone on the team remains "on the same page" and that using these files ensure that classes progress through the curriculum in a logical and efficient manner. Their belief is based on the fact that these files follow the curriculum as outlined in the textbook previously used in the course and align well with the contents of the textbook. Thus, deviation from the structure and order of the notes files causes trepidation for both Jennifer and Jessica. During one of their collaborative planning sessions, Sarah, who previously worked at another high school in the district, commented that the teachers in that high school had changed the order of the chapters so that chapter 9, rational functions, directly followed chapter 6, polynomials. The teachers at the other high school, she reported, felt that this helped students remember and reinforce their understanding of factoring. A long discussion about this option ensued, in which both Jennifer and Jessica expressed hesitation. In the end, they were

overruled by the newer teachers on the team, and the order was changed. Later in the year, after completing the rational units as well as the chapter 7 and 8 units, I asked all the teachers if they had observed any effects of this change in the chapter order; none reported observing significant changes. Yet, Jennifer and Jessica concluded that this meant they should revert to the original order, while the other three teachers concluded that they should retain the new order so that they were aligned with the other high school in the district.

Jennifer explains that she and the other teachers who originally created the notes files consciously followed the textbook; "we just kind of slowly condensed them into like 'well, this is good for section six point five or something. And we put it on google drive." Yet, she recognized that the "newbies", Sarah, Amada, and Emily, who began teaching Algebra 2 at their school after the advent of the Google drive, typically only review the materials on the drive, and do not generally relate the materials back to the textbook. Even Jessica, who began the Google drive endeavor, sees more of a difference between the textbook and the notes than Jennifer; "If you go to the text book it's still 6.8 the rational zero theorem, but the people before us already looked in the textbook and pulled off what we need them to know." Emily, in particular, is insistent that, although the notes files retain section names from the textbook, the contents are completely different; she feels "blessed" that the teachers that have come before her have created well-designed notes files with high quality examples that flow well throughout the lesson.

Regardless of the individual teacher's view of the relationship between the notes file and the textbook, the clear expectation is that each document in the notes folder

represents the backbone of one day's lesson. In other words, the number of documents in each notes folder represents the minimum number of days needed to teach the chapter. When the teachers find that they can devote more time to a particular unit, they turn to other folders, particularly the activities folders, for options to use during the additional days. However, activities are not solely reserved for "extra" days. Very often, but not always, the contents of the notes document for a particular day are insufficient for a full lesson. On these days, teachers supplement that curriculum in the notes with an activity.

Teachers' Planning Processes

In general, the teachers begin their lesson planning for a given chapter during collaborative meetings that occur after school hours as the previous chapter is coming to completion. The purpose of this collaborative meeting is to create a day-by day outline for the upcoming chapter. To do this, Jennifer typically consults a year-long plan that the collaborative team created at the beginning of the school year as well as announcements of activities, field trips, testing schedules, parent conference days, and other activities that may disrupt the usual class schedules. Based on this information, the team collaboratively decides on an end date for the unit, making sure that, if they change the originally planned end date of the unit, they will still have sufficient time for the remaining units, without a unit straddling winter or spring break. If they cannot work within these constraints, they will look for ways to divide one unit into two parts, giving a unit assessment at the end of each part.

Based on the determined end date and the files contained in the notes folders, the teachers determine how many days, if any, they can devote entirely to activities.

Once they have decided how many days of activities they are able to include in the unit, the teachers once again examine their calendars and school announcements to determine the best days on which to do activities and administer quizzes. Teachers resist giving goal quizzes or tests on Mondays or after a holiday or parent conference day on which students do not attend school, as they feel their students will not review material over the weekends. In addition, if there are days where there are likely to be large numbers of students absent for field trips, activities, or testing, they attempt to use that day as an activity day. Once they have chosen the days on which they will engage students in activities, usually two or three during the unit, they examine the contents of the activities folder to determine the best activity to use for each day. Here, the focus shifts from considering time constraints to considerations of student needs and interests, as well as what activity might flow well with the rest of the unit, given the activity day's placement in the unit. The chosen activities then become part of the 'mandatory' curriculum for that chapter that year, though in another year they may not be mandatory, and may not be used at all.

Once the mandatory curriculum for the unit is decided, the teachers work together to review and update the goal quizzes, tests, and chapter reviews, which are also included in the tests and quizzes subfolders. As they do, the experienced teachers discuss the challenges their students had with the chapter in previous years, mainly for the benefit of Emily and Sarah, who are new to the Algebra 2 team, but also for Amanda, who states that she is "still learning".

The teachers broke from this general routine for collaborative planning session for only one unit. Recall that Jennifer, Jessica, and Emily had created a guided inquiry

unit over the summer of 2016. This unit covered the content typically found in chapter 11. When it was time to discuss this unit, the teachers began to analyze the content of the created unit. Without much discussion or delay, they began to integrate the guided inquiry unit with the notes files that had been previously used for chapter 11. Thus, the guided inquiry unit written in the summer effectively became the activities used in chapter 11. Because these activities had never been tested in the classroom, much more of the discussion during the collaborative planning session focused on making decisions about how to implement the activities; how to group students, what resources to give to students, and how to assess their understanding. However, despite this deeper conversation, as the unit unfolded, each teacher made different decisions about what activities to emphasize and, as some of the activities took longer than anticipated, which activities to cut.

Despite this departure from typical procedures, after the collaborative planning sessions, the teachers continued to plan independently as they did for all units. Each teacher focused their planning on the notes and activities for the unit, and went through a process of integrating materials from the two folders, supplementing with additional materials only occasionally. This system gives the participating teachers a sense of common purpose and confidence in their plans for the lesson while maintaining autonomy. Sarah explained that "we do the planning and stuff together, so that gives me a guide and from there all of us do something just a little bit different but we have that shell we follow." In other words, the common structure still allows for independent decision making. This is important to the teachers, as Amada describes:

> I like being able to have the autonomy of deciding, ok, this is how I want to start my lesson, and not the textbook says we should start with

> example 1. So, maybe I want to start there maybe I don't. I like not having to be tied to that. I get to pick what I want. I can look at the notes that [Jessica]'s put up and go, yeah I'm going to use this, I'm going to use this, I'm going to use these problems, I'm going to take this off the internet, this funny joke and there you go. So, I like being able to pick and choose instead of just saying here's your textbook, here's your notes, go forth and example one, everybody.

Emily describes her process similarly. "I'll kind of filter through [the Google drive] like, oh, what do they got? And I'll tweak it for myself or pull up their notes and think about what I can do with them." Jessica, who uses similar methods to create her plans, often refers to the Google drive as a "resource bank", but is clear that she feels the resources in the Google drive are generally of higher quality than most online resource banks because it contains only those activities which have already been effectively implemented by teachers in their building. Thus, she feels more confident using the curriculum materials from the Google drive than she would using materials from other online resource banks.

When asked to describe how they decide which of the resources to use, all the teachers speak of the needs of their students as their primary consideration:

> Most of the time it's just based on my students. I mean, it changes year to year, class to class… When I think about the class of 34 versus the class of 20, the approach is a little bit different because there's not as many people to discuss and it depends on the people in the room too. The type of learners in the room with the larger group is way different than the types of learners in the smaller group this year. - Jennifer

Amanda speaks of the need to offer students a variety of activities, asking herself "do we need a day of structured, me going over problems, walking around, or do we need a day of… let's get up, let's move, let's apply, let's collaborate. And you kind of have to judge where your kids are, where timing is." Jessica explains that, because

they based their decisions on the needs of their students, they often wind up changing plans throughout the unit. If she feels that her students are not ready to move on, or if they did not do well on a goal quiz, she adjusts the plan to allow students to review the material already presented from another perspective, adjusting the rest of the chapter to ensure that all of the material deemed necessary is included.

Sarah uses a similar process not only in conjunction with Jennifer for the two sections of Algebra 2, but for her Algebra 2 Application courses, which support special needs students enrolled in Algebra 2. For her application courses, she pulls almost all the materials from the activities folders of the Google drive. She particularly looks for activities which support the instructional decisions she and Jennifer have made in the Algebra 2 classes, or that give students additional perspectives on material with which they are struggling.

It is important to note that, while the teachers generally choose the same activities to use in all their sections of Algebra 2, they also consciously make decisions to implement these activities differently in different sections. Sometimes, the differences in implementation were based on class size, as Jennifer explained. Other times, the differences were based on the results of goal quizzes, which students had been present or absent in the days leading up to a given lesson or were expected to be absent on the day of a given lesson, or feedback the teachers had gotten from students regarding what kind of activities they preferred.

The predominance of students in teachers' decision-making is obvious in their think-aloud sessions as well. Each teacher routinely commented on what they believed would engage or make sense to students. Sarah, in particular, focused on how well

different activities would engage students in conversations, which she believes is the key to student learning. However, other considerations also emerged. All the teachers were concerned with how much time would need to be devoted to different activities. When asked to compare the lessons reviewed in the think-aloud sessions, Jessica said she would use the lesson from their textbook if she was 'time-crunched' despite her belief that both other lessons reviewed were of higher quality. In addition, resources were often a concern for the teachers. Amanda decided that she was more likely to implement the lesson from *Discovering Advanced Algebra* than the *Light it Up!* lesson based solely on her perception that the materials needed for the latter would cost considerably more money.

Meaning-making was rarely restricted to planning sessions. Each teacher also made curriculum decisions while enacting the curriculum. These decisions were made predominately in response to students. For example, during one observation, Amanda took the time students spent working bell-work exercises to add a brief video to the anticipated lesson after one student requested a video on the way into class. She was able to do so only because of her familiarity with the activities folder, where a link to the video was stored. Similarly, Emily changed the order of her planned lessons one day when a significant number of students were unanticipatedly absent. The change allowed students to engage in a lesson incorporating independent work on that day, and allowed all students to participate in group work when the absent students returned the next day. Other teachers made similar changes to their anticipated plans while enacting the curriculum to respond to students or to other unanticipated events. For example, during one observation, after spending much of her first section trying to lead a whole-class

discussion over the din of nearby construction noise, Jessica altered her plans to allow students to have small group discussions instead. These in-the-moment changes demonstrated that planning for lessons continue as lessons are enacted.

Contributing to the Curriculum

While all the teachers have similar independent planning processes, there is one way in which their use of the Google drive differs significantly; each of the teachers have a different conception of when it is appropriate to upload new curriculum materials into the Google drive. Jennifer, the most experienced member of the team, seeks prior approval of the rest of the team before adding in additional materials; if the team does not seem to be interested in the materials, she often saves them on a separate flash drive. Likewise, if the team makes changes to the notes or other materials with which she disagrees, she will save a copy of the original file to her flash drive. Of all the teachers, Jessica is the most likely to change note files. Often, the changes are simply converting Interwrite™ files to PowerPoint™ files, because she fears that the school might replace the current interactive whiteboards with another brand or technology which may not be capable of reading Interwrite™ files, and is more confident that PowerPoint™ files will continue to be accessible. As she copies the notes into the new file type, she often also fills in information, like key definitions or theorems, as she goes. While Jennifer explains that she purposely likes to keep these blank, so she can engage her students in discourse in order for them to construct their own definitions and theorems, Jessica feels that taking the time to write in long definitions and theorems can take time away from activities, which she feels are more vital to student understanding.

Jessica is also the most likely to add something to an activity folder. Many times, the files she adds are new versions of activities used at other points in the curriculum, like the previously mentioned cups activities, or scavenger hunts, in which students must solve each problem in order obtain a clue to a puzzle or riddle, as well as be directed to the next problem. Oftentimes, after adding such an activity, she encourages Amanda and Emily to use the activity. She is Emily's mentor teacher, but unofficially mentored Amada as well and feels that she is more able to support these new teachers when they all use the same curriculum materials.

Amanda, who is in her third year of teaching, expressed that she has just started to feel confident enough in herself as a teacher to begin adding materials to the Google drive. Many of the materials she has added come from her experiences teaching a College Bound summer enrichment program at a local community college. While the program is not strictly aligned with Algebra 2 standards, when she identifies activities that address Algebra 2 standards and successfully engage the students she has in the summer, she saves a copy of the curriculum materials for that activity to the Google drive. In addition, Amanda is currently enrolled in a Master's program in mathematics education. As she is exposed to or develops activities as part of this program, she saves copies to the Google drive as well. While she is sure that activities discussed in her Master's program have been used successfully with students in the past, she admits the materials she creates for her Master's program have not been. However, she is willing to "experiment" and has successfully encouraged other teachers on the team to experiment with her materials as well. For one of her classes, Amanda developed a data and statistics unit centered around mathematics for social justice and proposed using the

unit materials for their unit on data and statistics. Emily and Sarah easily agreed, while Jennifer and Jessica required more convincing before utilizing these materials.

Sarah and Emily, the newest members of the team, have yet to contribute files to the Google drive. However, both of them occasionally use outside curriculum materials for their own classes. While Sarah explains that she does not add the materials into the Algebra 2 folder because she uses them exclusively in her Algebra 2 Applications classes, Emily feels that these materials are not yet ready for the Google drive; she wants to use them not just once, but multiple times to perfect them before sharing the materials with other teachers.

Discussion

The Google drive collection of curriculum materials emerged organically over a five-year period, and the results represent significant changes in the curriculum. While the organization of the curriculum largely remains the same as is presented in the previously used textbook, almost everything else has been either modified or eliminated. Formal definitions and theorems, when presented, retain the language used in the textbook, but the majority of these have been replaced by more informal, student-friendly definitions. Likewise, while many examples in the notes files are derived from textbook examples, these too have almost universally been altered by the participating teachers. The most significant change, however, is the inclusion of the activities folders; none of the files contained in these folders are derived from the textbook in any meaningful way. While no single activity is viewed as part of the mandatory curriculum in perpetuity like the notes are, each year the teachers collectively decide which activities are mandatory for the given year, and each teacher individually implements

additional activities as well. The structure itself, which not only allows but requires individual teachers to make their own decisions and adaptations, reflects a changing view of the relationship between teachers and written curriculum. The written curriculum is viewed by these teachers as a collection of tools to use, rather than a map to follow. As the teachers add curriculum materials, most often to the activities folder, the new materials expand their toolbox, rather than altering a map.

This view and organization of curriculum materials supports Brown's conception of teachers' use of curriculum materials as being on a spectrum, with strict fidelity of implementation on one end and full improvisation of the curriculum on the other (M. Brown, 2009). These teachers, as Brown suggests, move along the spectrum as they determine how materials from the activities folders can be integrated into their curriculum. However, the teachers are constrained in their ability to move along this spectrum by their hesitancy to adopt untested curriculum materials and desire to maintain the overall structure adopted from the previously used textbook. These constraints speak to the teachers' conscious efforts to maintain coherence, by largely only using activities that have previously been tested, and cohesiveness, by maintaining the overarching structures of the previously used textbook. Clearly Jennifer and Jessica, the more experienced teachers, were more concerned with these matters than the newer teachers, who more readily agreed to experiment with these structures, both when consider changing the placement of the unit on rational functions and when implementing the guided inquiry unit and social justice data and probability unit Amanda had created in her Master's program. Thus, experience may play a role in

determining how concerned teachers are with maintaining coherence and cohesiveness and how willing teachers are to adopt new curriculum materials.

Other factors also impact what curriculum materials the teachers select. Both in collaborative and individual planning sessions, these teachers considered not only the needs of their students, but their interests and past successes with various activities as well. In addition, the anticipated absence of various students impacted the teachers' decision-making, as did considerations of timing and available resources. Taken together, it is clear that it is not just teachers and curriculum materials that determine the enacted curriculum; the students and the context in which lessons are implemented also play a role.

Towards a Transactional Systems View of Curriculum

Adaptive implementation theories have served as foils to theories of fidelity of implementation and have been regarded as the opposite end of a spectrum of views on curriculum implementation (Cho, 1998). However, these theories only consider the role of the teacher and of the curriculum materials in implementing curriculum. Yet, other factors clearly influenced the participating teachers' use of curriculum materials; they reported and were observed changing the curriculum materials they used, as well as how those materials were used, not just on a day-to-day basis, but on a class-to-class basis. These teachers considered the needs, preferences, and absences of various students, time constraints, and availability of resources when they chose which of the Google drive curriculum materials to use as well as when they reviewed unfamiliar curriculum materials. These findings support previous findings about the factors that

influence teachers' use of curriculum materials (e.g. Ben-Peretz, 1990; Lloyd et al., 2009; Remillard, 2000, 2005).

It is important to distinguish between the influence of students, time, social and cultural factors, and support given to teachers on one hand, and teachers' perceptions of these influences on the other. Some may argue that it is only the teachers' perceptions of these factors that impact teachers' use of curriculum materials, and thus they do not directly impact curriculum. However, in reality, both the perceptions of these factors and the factors themselves influence teachers use of curriculum materials. Consider, for example, the impact that anticipated absences had on the decisions of the participating teachers. When teachers anticipated absences, their plans were clearly impacted. However, even when absences or other disruptions, like construction noise, were unanticipated, the event prompted teachers to alter plans. Thus, both students and context can impact both the intended and enacted curriculum.

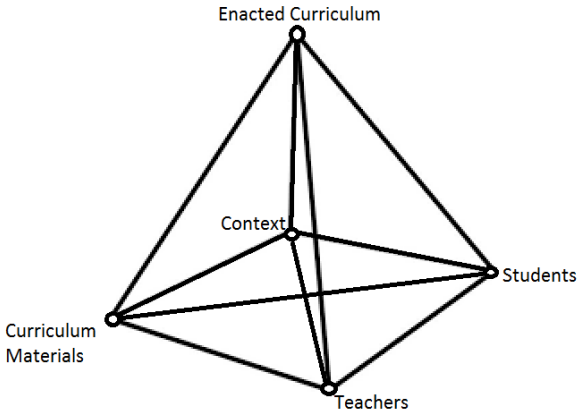
Various theories examine the impact of both context and students on the curriculum. For example, enactment theory (Cho, 1998; Snyder, Bolin, & Zumwalt, 1992) posits that teachers' and students' uses of curriculum materials impact each other and that, in this way, teachers and students work together to make meaning of the curriculum materials. Thus, students influence the use of curriculum materials as well as teachers' perceptions of their students. Additionally, some researchers studying the use of curriculum materials now utilize reader response theory, which assumes that the perceiver and the perceived are both aspects of a system of meaning making, to describe the process of developing curriculum from curriculum materials (Remillard, 1999, 2005; Siegel, Borasi, & Fonzi, 1998; Weinberg & Wiesner, 2010). Reader response

theory also claims that the context in which a text is read influences the meaning made from the text. Thus both students and the perceptions of students, context and perception of context are aspects of the system of meaning making (Remillard, 2005). Other theories which examine the modes in which teachers engage with curriculum materials describe teachers' actions as collaborating or participating with curriculum materials in order to construct the intended curriculum (McClain et al., 2009; Remillard, 2005). Proponents of these theories seek to understand the transactions of the teacher and the text and accepts that they are influenced not only by teacher beliefs and knowledge, but the context in which they teach as well. Additionally, these theories claim that teachers' stance towards curriculum materials, that is, their purpose in reading, also impacts the meaning made from the curriculum materials (Remillard, 2015).

Defining Transactional Systems

Taken together, enactment, reader response, and modes of engagement theories can be thought of as emphasizing different aspects of a larger transactional system in which curriculum materials, teachers, students, and local contexts work together and through each other to enact curriculum. This describes what Dewey and Bentley referred to as a transactional system; in a transactional system, aspects continually act on, and are acted upon, by the other aspects of the system. Therefore, transactional systems can only be understood by studying the system in its entirety. In other words, no single aspect can be fully understood without examining the ways in which the other aspects of the system transact with it (Dewey & Bentley, 1949).

Figure 5: Transactional System Model of Curriculum



The concept of a transactional system was foundational in Rosenblatt's transactional theory, on which much of reader-response theory relies. According to Rosenblatt's transactional theory, when a text is read, the aspects of a transactional system (including the reader, the text, and the context) work interobjectively to create meaning. In other words, each aspect acts with and through the other aspects in order to create meaning (Rosenblatt, 1978). The theory relies on the concept of a stance towards a text as discussed above. Thus, theories about teachers' modes of engagement explicitly rely on transactional theory.

From the perspective of transactional theory, the enacted curriculum can be viewed as the meaning made from a transactional system that consists of curriculum materials as texts, teachers and students as readers (both of text and of each other) and local school structures, cultures, policies, and procedures as context. Thus, the relationship between teachers and curriculum materials is just one aspect of the larger transactional system of curriculum implementation. Analysis of the transactional curriculum system must seek to illuminate how each aspect of this transactional system influences the others.

If we adopt the perspective of curriculum as a transactional system, we must reexamine several fundamental questions. First, if curriculum may be shaped and dramatically changed while being enacted, then how can coherence and cohesiveness be ensured? The teachers participating in the study clearly attended to these issues. Not only did they discuss changes in the content or logical ordering of the curriculum units at length during collaborative planning sessions, but the use of the Google drive itself serves to ensure coherence and cohesiveness because the teachers have agreed to use the notes files on a daily basis. Yet, the ability of teachers to adjust the curriculum to meet the needs presented by their students and contexts is maintained by allowing them choices in the activities they integrate into the notes and chapters. This, however, raises an even more fundamental question: is the content of the notes folders representative of the essential elements of an effective mathematics curriculum? Certainly, these files address the content standards developed in the Oklahoma Academic Standards for Mathematics, however, because these files are largely utilized in lecture-based lessons, the process standards contained within the state standards, which call on students to model, conjecture, problem solve, and make sense of mathematics, among other things, are largely ignored and addressed only during optional activities (Oklahoma State Department of Education, 2016).

It is not clear whether the content of the notes files was deemed the essential content by the participating teachers because of their understanding and beliefs about what mathematics curriculum should be, or if the content is simply a reflection of the content deemed essential by the previously used textbook. What is clear is that the participating teacher still rely on traditional lecture-based lessons, however minimally,

to provide coherence and cohesiveness to the curriculum. Even when presented with a fully developed guided inquiry unit, the teachers felt the need to integrate that unit with the previously developed notes in order to ensure coherence. Thus, teachers who have relied on traditional lectures to form the basis of their curriculum may need significant professional development to trust another framework to provide adequate coherence and cohesiveness. This too, raises significant questions. Not only must we ask how teachers could come to trust another curriculum framework, but we must also ask what such a framework might look like. Perhaps such a framework would look much like the Google drive and provide both essential and optional elements while simply changing the nature of the essential elements to be more reflective of effective principles of mathematics teaching and learning. However, it is also possible that another structure could more effectively and efficiently ensure coherence and curriculum while allowing teachers adequate autonomy to respond to the needs of their students and contexts.

Whatever we might imagine for the future, the days of textbook-as-curriculum are over. Whether working individually or in small collaborative groups, secondary mathematics teachers like those in this study will continue to find and use curriculum from diverse resources. How we can ensure that the resulting curriculum is effective, coherence, and cohesive is a serious question that must be addressed both in terms of professional development and curriculum development.

Chapter 3: Teachers' Meaning-Making Processes

Traditionally, changes in curriculum materials have been seen as the primary means of mathematics education reform (Larson, 2009; McClain, Zhao, Visnovska, & Bowen, 2009). However, teachers are increasingly consulting additional sources of curriculum materials beyond those adopted by their districts, including web based lesson resources and exchanges (Abramovich, 2013; Drijvers, 2015). In part, this may be due to an increase in guiding documents, like national or state standards, with which a specific textbook may not align (Usiskin, 2010). When teachers are given only broad standards or guidelines to follow rather than a specific text, they have more freedom to make curriculum choices (Ben-Peretz, 1990). There is significant evidence that the vast majority of teachers now select at least some of their curriculum materials themselves (Larson, 2016). According to a study by the Education Development Center, almost half of teachers in a STEM content area routinely search for curriculum materials online (Abramovich, 2013). The availability of extensive online resources has fundamentally changed the ways in which teachers interact with curriculum materials. Before this technology, the quality of curriculum resources teachers encountered was controlled by publishing companies and district supervisors; the availability of internet based teacher resources eliminates these control factors (Abramovich, 2013). This greatly increases the chances that curriculum coherence is lost as teachers adapt materials from a wide variety of sources and as students move between teachers who utilize different curriculum materials (Larson, 2016). That is, by using multiple sources created for multiple purposes by multiple people, teachers risk failing to create a curriculum that

develops “important mathematics along coherent learning progressions” (NCTM, 2014).

Studies have documented some of the factors that influence how teachers use curriculum materials, but there is still much we do not know. For example, we know that teachers’ work with curriculum materials has a profound impact on the curriculum (Ben-Peretz, 1990), but we know little of specific processes teachers use in their interactions with curriculum materials (Remillard, 2005, 2009). We know that teachers’ use of materials is influenced by their knowledge and beliefs (M. Brown, 2009). We also know that teachers are able to make decisions about what materials to read and what not to read (Remillard, 2005). However, we know very little about how teachers select from among the curriculum materials available to them.

We can, however, say that the processes by which teachers compare, contrast and evaluate different curriculum materials necessarily involve making meaning from those curriculum materials. The purpose of meaning making is to determine “the potential of the curriculum materials so that these can be reconstructed for particular students and for specific classroom situations” (Ben-Peretz, 1990, p. xiv, 66, 87). In order to adapt curriculum materials, teachers must be able to extract multiple potential meanings or themes from the curriculum materials (Ben-Peretz, 1990). Only once teachers perceive these meanings can they begin to interpret the meanings in light of their context and students (M. Brown, 2009). How teachers engage in meaning making and the processes by which they make meaning are therefore of critical importance if we are to understand how teachers use vast arrays of curriculum material to enact

coherent curricula. Yet, there has been little research into how teachers make meaning from curriculum materials (Remillard, 2000).

This case study represents a first step towards forming an understanding of how one group of secondary mathematics teachers make meaning from curriculum materials. It utilizes reader response theory and metacognition as theoretical lenses through which the meaning making process of four mathematics educators and one special educator at one suburban high school in a southern plains state are analyzed. Reader response theory posits that meanings made during reading depend upon several factors, including the intended purpose of reading, the reader's confidence as a reader of the text, and the reader's ability to construct meanings using multiple perspectives. Further, reader response theory argues that once one or more potential meanings are constructed by the reader, the meanings must then be interpreted. This interpretation necessarily requires metacognition as the readers reflect on the meanings they constructed and the evidence within the text that support those meanings. Using these theoretical frameworks, several questions must be asked about teachers' meaning making with curriculum materials: with what purpose do teachers read curriculum materials, how confident are they in their ability to make meaning from and interpret curriculum materials, to what extent are multiple meanings made by the teachers, and what metacognitive behaviors do teachers use to regulate and interpret the meanings they make?

Teachers' Work with Curriculum Materials

Studies have found that a myriad of factors influence how teachers use curriculum materials. Some of these influences are internal to the curriculum materials themselves, while others are external factors that depend upon characteristics of the

teacher using the curriculum. These factors do not work in isolation; each factor may influence others. For example, the presence or lack of suggestions for adaptations within curriculum materials clearly may influence the way in which a teacher uses them. However, what adaptations they choose to make may depend on the teachers' knowledge of their students and what kinds of adaptations may benefit them (Ben-Peretz, 1990). Thus, both internal and external factors work together to influence how teachers construct and enact the curriculum. The sections that follow highlight some of the factors that influence teachers' curriculum use, including the structure and content of the curriculum materials, teachers' perceptions of the materials, and teachers' knowledge, abilities, beliefs, identity and experience.

Characteristics of Curriculum Materials that Influence Use

The nature and organization of curriculum materials, tasks included in them, and the support offered to teachers all influence how teachers use them (Remillard, 2009; M. Stein & Kim, 2009). Many curriculum materials have been designed to facilitate teachers' adaptations by using a structure which both allows and suggests potential adaptations and modifications. Teachers who lack the confidence to make such adaptations may prefer curriculum materials that offer a more scripted view of the curriculum; these scripted curriculum materials, however, threaten the autonomy of teachers who are more confident in adapting materials (Ben-Peretz, 1990). Thus, the nature of the materials may, in part, determine if a teacher uses it at all. Even if teachers are confident in adapting materials, curriculum materials that present a significantly different view of mathematics and mathematics teaching and learning (such as many of the NSF funded standards-based curriculum materials) have been found to present

challenges for many teachers (Remillard, 2015). These challenges may be due, in part, to the teachers' perceptions of the curriculum materials themselves.

Perceptions of Curriculum Materials

How teachers use curriculum materials depends upon their perceptions of the materials, which, in turn, are influenced by teachers' beliefs about the nature of mathematics and teaching (Drake & Sherin, 2009; Remillard, 2015). When adapting new curriculum materials, teachers may be concerned about the content of the material as well as whether the materials are appropriate for their particular students or if the content is too easy or too difficult (Ben-Peretz, 1990; Shulman, 1986). As they begin to use new curriculum materials, teachers rarely understand what the views of the curriculum developers were and lack curriculum vision and trust (Ben-Peretz, 1990). Curricular vision is the understanding that teachers have about the goals of the curriculum materials, while curriculum trust refers to teachers' perceptions of how well the curriculum materials will facilitate students as they move towards the goals set out in the curricular vision (Drake & Sherin, 2009). Without curriculum vision and trust, teachers may have difficulty using curriculum materials.

Whether teachers believe that the curriculum materials share their orientation towards mathematics and mathematics teaching and learning is an important factor in their use of curriculum materials (Remillard & Bryans, 2004). The effects of these concerns and beliefs about particular curriculum materials are also mediated by teachers' stances towards curriculum materials in general; whether they believe curriculum materials are authoritative or are simply a tool to be used. Teachers' stances towards curriculum materials have an even greater impact on their use of those

materials than their concerns or questions about the content and vision of specific curriculum materials (Remillard, 2005; Remillard & Bryans, 2004).

Characteristics of Teachers that Influence Use of Curriculum Materials

Teachers' perceptions of curriculum materials are just one of a whole host of teacher characteristics that influence the design of the intended curriculum. In fact, teacher characteristics play a larger role in the development of the intended curriculum than the content of the curriculum materials (Remillard, 2000). Brown identifies teachers' knowledge and beliefs as the primary influences on their use of curriculum (M. Brown, 2009). Others have also included teachers' professional identity and experiences (Lloyd & Pitts Bannister, 2010; Remillard, 2005; Remillard & Bryans, 2004). Difference in individual teachers' knowledge, beliefs, experience, and identities not only explain why the same curriculum materials are implemented in very different ways by different teachers, but may also explain why different teachers utilize different curriculum materials; simply put, "what works for one may not work for another." (Usiskin, 2010, p. 26)

Teachers' Knowledge and Beliefs

Mathematics teachers rely on three types of knowledge as they use and adapt curriculum materials: content knowledge (knowledge of the subject), pedagogical knowledge (knowledge of teaching), and pedagogical content knowledge (pedagogical knowledge particular to the specific content being taught) (Shulman, 1986, 1987). Pedagogical content knowledge includes knowledge of those topics most regularly taught within the content, how students can be effectively engaged in those topics, and different ways those topics can be usefully represented, explained and or demonstrated

to students and is determined both by research and experience (Ben-Peretz, 1990; Shulman, 1986). This knowledge becomes even more critical in constructivist, inquiry-focused classrooms in which teachers are expected to respond to the constructions and understandings of students (Shulman, 1987). Without well-developed knowledge of all three types, teachers are unable to determine the ways in which curriculum materials could be adapted.

It should be noted that, within the literature, there is some disagreement about the difference between knowledge and beliefs. In general, however, knowledge is considered a subset of beliefs that have been justified and are held with certainty (Philipp, 2007). Thus, a given understanding can be considered knowledge for one teacher and a belief of another. For example, consider teachers' knowledge or beliefs about the nature of mathematics itself; whether they understand mathematics as a dynamic process of problem solving, or as a static body of knowledge consisting of proven rules and relationships (Felbrich, Kaiser, & Schmotz, 2012). Some contend that this is knowledge and is the "greatest influence" on how teachers implemented mathematics curriculum (Manouchehri & Goodman, 2000), Other sources have categorized teachers' understandings of the nature of mathematics as a belief. While these studies do not claim that this belief is the greatest influence on the implemented curriculum, researchers generally agree that it does affect the intended curriculum. For example, teachers that view mathematics as static and rule driven have been shown to spend significantly less time planning and preparing mathematics lessons than those who view mathematics as dynamic problem solving (A. Thompson, 1984). This may indicate that these teachers spend less time considering ways in which the curriculum

can be adapted.

It is not simply teachers' beliefs about the nature of mathematics that influence their use of curriculum materials. Teachers' beliefs about the nature of teaching also have a significant impact (A. Thompson, 1984). For example, if teachers see themselves as facilitators, they may spend more time anticipating student responses or potential difficulties than teachers who see their role primarily as a conduit of information (Remillard & Bryans, 2004). Teachers' beliefs about the purpose of schooling and the nature or quality of various reform movements have also been shown to influence teachers' use of curriculum materials (Usiskin, 2010).

It is important to note that teacher belief structures are not static; as teachers work with materials and reflect on the curriculum they have enacted, their belief structure may change. This may cause teachers to struggle in evaluating different curriculum materials and determining how best to use them in their classrooms (Remillard, 2000; Usiskin, 2010). Additionally, the beliefs that teachers hold may be consciously or unconsciously held, thus complicating teachers' ability to understand, or at least articulate, the reasons they use particular curriculum materials in particular ways (A. Thompson, 1984).

Teachers' Identities and Experiences

In constructivist classrooms, teachers need to be able to anticipate the thinking and actions of their students. To do so, teachers must understand the skills, experiences and knowledge students already hold (Breyfogle, McDuffie, & Wohlhuter, 2010). The ability to do so is greatly impacted by experience in the classroom. There is little research about how teachers use curriculum materials during different phases of their

career, or why or how these differences occur (Behm & Lloyd, 2009). We do know that, as teachers gain experience and are better able to anticipate the knowledge and needs of their students, they are more able and likely to focus on big goals for their classrooms and are better equipped to make adaptations to curriculum materials to meet the needs of their students (Ben-Peretz, 1990). Without such experience, preservice teachers tend to rely more on their teacher education and content knowledge as well as their confidence as a teacher (Behm & Lloyd, 2009).

This confidence in teaching is part of a teacher's professional identity. Professional identity includes teachers' beliefs about their efficacy as a teacher, a user of curriculum, and as an authority in the classroom. Teachers' feelings of self-efficacy greatly influence the decisions about how to adapt curriculum materials, especially when teachers are asked to use curriculum materials that promote teaching in unfamiliar ways; essentially, to adapt to new ways of teaching requires teachers to reform their identity as a teacher (Remillard, 2005).

The discussion above summarizes some of the key influences on teachers' use of curriculum materials. Next, I turn to the specific ways teachers use curriculum materials. This requires examination of the relationship between the written curriculum materials and the intended curriculum, as well as the processes teachers use in constructing the intended curriculum (Remillard, 2005).

Teachers' Use of Curriculum Materials

Studies that have examined teachers' use of curriculum materials show the process to be highly complex, interactive, and intellectual (Lloyd et al., 2009; Remillard, 2005). Teachers reason with, interpret, evaluate, and reflect on curriculum

materials. Further, depending on how they are used, curriculum materials may either constrain teachers' practices, or expand them (M. Brown, 2009). Teachers must make meaning from, reason with and about curriculum materials, and make instructional decisions based on those materials. Curricular reasoning, the processes by which teachers use curriculum materials to "plan, implement, and reflect on" the curriculum of their classes, involves being able to comprehend and analyze materials, map cohesive instructional plans, adapt and use curriculum materials, evaluate their effectiveness and reflect and revise those plans (Breyfogle et al., 2010; McDuffie & Mather, 2009, pp. 305–306; Shulman, 1987, pp. 15–19). Based on curricular reasoning, teachers make choices about what tasks and activities are appropriate, and what elements should be emphasized, included, excluded, or adapted (Ben-Peretz, 1990; Cuoco, Benson, Kerins, Sword, & Waterman, 2010). Teachers make these decisions daily; the intended curriculum is the result of these decisions and significantly impacts the learning of students (Reys et al., 2010; D. Thompson & Senk, 2010).

When using primarily a single source of curriculum, usually a textbook, teachers restrict themselves in the kinds of decisions they make; generally, teachers change little of the themes or sequencing of the curriculum materials, focusing instead on decisions about which themes or messages to emphasize, and what instructional activities to use (Ben-Peretz, 1990). This may be an attempt, conscious or not, to maintain curriculum coherence. However, when teachers make more adaptations, or use more diverse sources of curriculum, they run the risk of making changes of sufficient quality or quantity as to distort the original intentions of the primary source of curriculum, causing curricular confusion (Ben-Peretz, 1990). Curriculum coherence refers to the extent to

which logical, conceptual, and pedagogical connections exist within and between lessons; curriculum materials that span multiple lessons, such as textbooks, are designed to ensure coherence (Larson, 2016). By adhering to the themes and messages of sets of curriculum materials designed as a package, teachers maintain some of the coherence of the original design.

The question, then, is not if teachers adhere to the intent of curriculum designers, but rather to what extent they adhere to these intentions. One way in which this has been studied is by measuring textbook integrity in classrooms. Textbook integrity is defined as the "extent to which the district adopted textbook serves as a teacher's primary guide in determining content, pedagogy, and the nature of student activity" (Chval et al., 2009, p. 72). Studies have measured textbook integrity by examining how often the textbook is used in lessons, how much of the textbook is utilized during a year, and how the adaptations of teachers align with the "pedagogical orientation" of the textbook. Not only have these studies found that textbook integrity varies between teachers and textbook series, but a single teacher may show high textbook integrity in one class and low integrity in another, even when using the same curriculum materials (Chval et al., 2009). In other words, teachers make multiple meanings from the same curriculum materials.

Reader Response Theory

Reader response theory gives a framework with which to study the evocation of multiple meanings from curriculum materials. Based on Rosenblatt's transactional theory of meaning making, reader response theory claims that meanings evoked from a text depend upon the reader in several key ways, including their purpose for reading,

their identity and confidence as a reader, and their ability to view the text from multiple perspectives (Appleman, 1992; J. E. Brown & Harrison, 1992; Furniss, 1992; Luce, 1992; Quinn, 1992; Rosenblatt, 1978).

When teachers read curriculum materials, they evoke meanings with which the intended curriculum is created. This intended curriculum, while not written, might also be considered a text as well as it consists of the cues and symbols, both written and verbal, with which both practitioners and learners transact to evoke the enacted curriculum. Thus, reader response theory posits many questions about how teachers make meaning with curriculum materials, both as they read the written curriculum materials and as they enact the intended curriculum. In particular, what do teachers view as the purpose of reading curriculum materials, how confident are they as users of curriculum materials, to what extent do teachers view the curriculum materials from multiple perspectives, and how does the school context in which they work influence the meanings made?

It is important to note that reader response theory allows for the reader to create different meanings when reading a text for different purposes or under difference circumstances, but also posits that a reader may create multiple potential meanings during the same reading which they then must interpret to decide the most likely, or highest quality, meaning (Rosenblatt, 2005). Thus, beyond examining how potential meanings are made, we must ask what processes teachers use to choose among the possible meanings made. This question of interpretation is of vital importance; interpretation of meanings of curriculum materials are necessary if teachers are to evaluate the quality of said materials. It is important to distinguish between evoking

meaning and interpreting meaning; the reader can have no interpretation until the meaning of the text is developed. However, having developed one, or multiple meanings, the reader is free to create any interpretation supported by, and not contradicted by, the text (Rosenblatt, 1978, p. 115). Thus, a teacher, like any reader, must be able to determine the ways in which the various responses are supported by elements of the text before creating an interpretation of the text based on the best evidence collected (Luce, 1992, pp. 69–72). This interpretation, then, requires metacognition; a teacher must think about the possible meanings they have made from curriculum materials (that is, what they think the meaning might be) and evaluate which meaning is most likely, based on the text and which text or texts might be the most meaningful in their classroom.

Metacognition

The term metacognition was first coined by John Flavell, who originally defined it to be "one's knowledge about one's own cognitive processes and products or anything related to them" (Flavell, 1976, p. 232). He described metacognition as both "the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects of data on which they bear" and, in a later article, "the knowledge and cognition about the cognitive objects, that is, about anything cognitive" (Flavell, 1976, p. 232, 1987, p. 21). These two descriptions of metacognition demonstrate that metacognition is ill-defined; the first describes metacognition as an active process or set of behaviors, the second as a specific type of stored knowledge. Both conceptions of metacognition are multifaceted, with several components that act on and are informed by each other. The focus of this study, however, is on the

observable behaviors of teachers, and thus uses the view of metacognition as a set of behaviors.

Metacognitive Behaviors

Metacognitive behaviors are those "activities used to regulate and oversee learning" (A. Brown, 1987, p. 68). Originally, Brown partitioned metacognitive activities into three main categories: planning, monitoring and evaluation. However, she later added a fourth category, predicting, to this framework. Predicting differs from planning in that predicting is concerned with the likelihood of success, while planning is concerned with the process of completing the task (A. Brown, 1987; Desoete, 2007, p. 708). Information management and debugging strategies were also added to this list (Schraw & Dennison, 1994, p. 460). Each of these categories have been further subdivided. For example, Nelson and Naren (1994) divided metacognitive monitoring, which is the ability to self-check one's success at attempts of cognition, into fours subcategories, which they termed 'judgements' (Loizidou & Koutselini, 2007).

The literature on metacognitive activities is not consistent in the categories used. In creating a metacognitive awareness inventory for teachers, Balcikanli used only three categories for metacognitive activities; planning, monitoring, and evaluation (Balcikanli, 2011, p. 1318). On the other hand, when examining the interrelatedness of locus of control, epistemological beliefs, and metacognition in early childhood educators, Bedel used the five categories identified by Schraw and Dennison (Bedel, 2012, p. 3053). Not only does the use of various frameworks make comparisons of studies difficult, but the distinction between the different categories is not a clear as it may appear on the surface. For example, metacognitive monitoring might prompt

reflection on what has already been accomplished to plan for what to do next. That is, one activity can be activated by monitoring, but utilized for both reflection and planning. Regardless of categorization, however, metacognitive behaviors are necessary if teachers are to interpret curriculum materials in meaningful and coherent ways.

Methodology

This study used an interpretive instrumental case study method to investigate how a group of five secondary mathematics teachers at a large suburban high school in a southern plains state created a cohesive and coherent curriculum from diverse curriculum materials in order to "illustrate, support, or challenge" the current models of teachers use of curriculum materials (Merriam, 2009, 28). A case study methodology was chosen specifically because reader response theory posits that meanings created from text depend significantly on the individual readers, their purpose for reading, and the context in which they read. Thus, meaning making can only be studied in a particular place and time with particular teachers.

This study focused on the five Algebra 2 teachers at a large suburban high school. The participants, four mathematics educators and one special educator, are the only Algebra 2 teachers at their school. Five years ago, they, as a team (though some members of the team have changed) made a choice not to rely on the district-provided textbook as their primary source of curriculum and instead build their own curriculum material library. This process has been continual for these teachers; they are consistently adding materials to the curriculum library as well as refining materials already included in the library.

For the 2016-2017 school year, the state in which these teachers worked adopted new standards for mathematics. In the summer before the school year, three of the five participants attended a two-day professional development workshop focused on the new standards that I helped their district curriculum supervisor develop and facilitate. In addition, during the same summer, three of the teachers also participated in a week long professional development workshop focused on the use of guided inquiry in secondary school settings. During this workshop, the participating teachers created a new unit of curriculum materials focused on sequences and series which utilized guided inquiry methods. Together, the new standards and new unit created a unique opportunity to study how teachers make meaning from new curriculum materials. In particular, I sought to understand with what purpose the participating teachers read curriculum materials, how confident they are in their ability to make meaning from and interpret curriculum materials, the extent to which they make multiple meanings, and the strategies they use to interpret the meaning or meanings made from curriculum materials.

This case was bounded by both time a place in that it specifically examined the meaning making of Algebra 2 teachers at a specific school during the 2016-2017 school year, which presented multiple opportunities to observe these teachers making meaning from the new state standards, the teacher created guided inquiry unit, and other new materials the participating teachers incorporated into their curriculum library throughout the year. Data were collected through interviews, observations, and document analysis. These data were analyzed using an interpretive perspective that sought to understand how each participant interacted with the currently developed curriculum as well as with

new curriculum materials, conscious that the process of each teacher depended upon the specific context in which each participant practices (Merriam, 2009).

Settings and Participants

Because reader response theory posits that both the purpose and the context in which meaning making occurs can influence the meaning made, it is important to examine both the participating teachers and the school setting in which they work, which is in a suburban town in a southern plains state. The high school has a history of excellence in mathematics; multiple teachers in the mathematics department have received district, state, and national recognition for their teaching. The student body, approximately two thousand students, is largely white, with significant Hispanic, Black, and Native American Populations (Oklahoma Office of Educational Quality and Accountability, 2015). Though the average household income is significantly above state averages, almost half of the students are eligible for free and reduced meals and poverty and unemployment rates are consistent with state averages (Oklahoma Office of Educational Quality and Accountability, 2015). Thus, there is a fair amount of income inequality among the students at the school.

Each of the participants teach multiple sections of Algebra 2, as well as sections of other courses such as geometry, math analysis, and Advanced Placement calculus. Emily, a first-year teacher, taught two sections, while the other three mathematics educators taught four sections. Sarah, the special educator on the team, co-taught two sections of Algebra 2 with Jennifer, as well as Algebra 2 Applications, a course designed to support special needs students in Algebra 2. Algebra 2 is the highest-level mathematics students must complete to graduate. As such, all students in the high

school take Algebra 2 and classes may have students of multiple ages, grade levels, and previous experiences in mathematics.

Table 5: Certification, Education, and Experience of Participating Teachers

Pseudonym	Certifications	Degree(s)	Previous Years of Teaching Experience
Jennifer	Traditional Certification Secondary Mathematics	B.A. Math Education	11
Jessica	Alternative Certification Secondary Mathematics	B.A. Mathematics M.A. Mathematics	8
Sarah	Alternative Certification Special Education	B.A. Psychology M.A. Special Education	5
Amanda	Traditional Certification Secondary Mathematics	B.A. Math Education*	2
Emily	Traditional Certification Secondary Mathematics	B.A. Math Education	0

**Amanda began a M.A. in Mathematics Education in the summer of 2016.*

I came to know Jennifer, Jessica, Amanda, and Emily through my work as a field supervisor for student interns; Jennifer and Jessica were mentor teachers to students and Amanda and Emily are former student interns whom I supervised. Sarah and Emily both began working at the high school in the 2016-2017 school year, when the study was conducted. Each teacher expressed the desire to continuously innovate in their classrooms. These teachers work closely with each other when planning for their Algebra 2 classes. Their desire to innovate and their culture of working and planning together meant that these teachers engaged in developing and evaluating their current curriculum on a regular basis. Thus, there were significant opportunities to observe meaning making with various curriculum materials.

Data Collection

Qualitative research depends on the use of multiple sources of data so that the situation under investigation can be viewed from multiple perspectives (Yin, 2011). As such, this case study used interviews, think-aloud sessions, and observations. Three forty to sixty minute semi-structured interviews were conducted with each participant over the course of two months. The first interview focused on the participating teachers' beliefs, knowledge, and values about mathematics, teaching, and learning as well as the educational and teaching experiences. The second interview focused specifically on their understanding of and experiences with the curriculum they used in Algebra 2. Finally, the third interview focused on what teachers valued in curriculum materials and how they made decisions about which curriculum materials to use. The semi structured nature of these interviews allowed informal follow-up questions to be asked when warranted (Merriam, 2009). Participants were also observed as they reviewed curriculum materials for use in their Algebra 2 classes. During the study, the five participants met as a group to plan for Algebra 2 on three separate occasions. These planning sessions were also observed. Field notes were taken during both individual and collective observations.

The participants were also observed as they enacted the lessons they planned. The purpose of observations was to examine aspects that would otherwise be overlooked by participants and record these aspects without engaging in interpretation (Merriam, 2009; Schwandt, 2015; Stake, 1995). Discrepancies between the written curriculum plan and the observed lesson were then discussed with participants in informal interviews following the lessons. Each participant was observed on six

different dates. For the first three observations, each teacher was observed throughout the day, both as they planned and as they enacted lessons to multiple sections of Algebra 2. The purpose of these observations was to focus on the aspects that were consistent for each section in which the lesson was enacted, as well as the discrepancies between different sections. For the final three observations, each of the five teachers were observed enacting a lesson based on the same curriculum materials to more directly observe differences in the enacted curriculum of the participants.

Finally, each participant engaged in three "think aloud" sessions. During these sessions, participants were asked to think aloud as they reviewed curriculum materials; the spoken thoughts were then coded as an additional source of data (Bannert & Mengelkamp, 2008, p. 43). These sessions engaged teachers in sharing what they were thinking, doing, or feeling as they made meaning from curriculum materials. After they had fully reviewed the curriculum material, they were asked to share their thinking about specific portions of the curriculum materials to draw out further insights. This structure gave insight into both the meaning making teachers naturally engage in when reviewing curriculum materials, and the meanings they can make when prompted. It is from these think-aloud sessions that the majority of the findings about how teachers make meaning with written curriculum is drawn. Interviews and observed planning sessions provide supporting evidence of teacher thinking when working with curriculum materials, while observations of enacted lessons shed light on how teachers make meaning while enacting intended lesson plans.

Three lessons were supplied for use during think aloud sessions. Each of them broadly addressed the same content, rational functions. This content was chosen

because the curriculum created by the teachers included a chapter on rational functions, which was the first unit observed for this study. The think aloud sessions all took place within a month after the completion of the unit so that the material contained in the unit was fresh in the minds of the participating teachers.

The first lesson supplied, entitled *Light it Up!*, is from NCTM's Illuminations website, which aims to increase "access to quality standards-based resources for teaching and learning mathematics" (NCTM, n.d.). The lesson centers on a cooperative learning activity embedded in a real world context that provides scaffolding for students through the development of rational function models by having students explore relationships between problem contexts, equations, and graphs (J. Nelson, n.d.). Specifically, this lesson presented several related scenarios around the concept of the cost per student of going on a field trip to a fair. In the culmination of the lesson, students are asked to place a mirror on the floor, point a laser at the mirror from several different distances, and record the height of the reflecting of the laser point on a wall. The lesson plan provided significant support to teachers in the form of suggested questions to ask students, indications of when to pause for whole class discussion, and potential modifications directly within the text of the lesson plan.

The second lesson supplied, entitled "Introduction to Rational Functions*"* was drawn from a teacher's edition of a textbook entitled *Discovering Advanced Algebra: An Investigative Approach* (Murdock et al., 2010), with which some of the participating teachers were slightly familiar, as they have drawn material from it for use in their classes. The aim of the publisher is to allow students to "concretely explore interesting problems and generalize concepts… to form a deep and conceptual understanding of

advanced algebra topics." (Murdock et al., 2010, p. v). The specific lesson asked students to add weights to a strand of spaghetti cantilevered off the side of the table until it breaks. By varying the length of the strand that is cantilevered and plotting the weight needed to break the strand as a function of the length of the strand, student construct the graph of a rational function. This lesson provided some teacher support in the form of potential questions and modifications as well as alerts to potential challenges in the margins of the text.

The final supplied lesson was taken from the textbook which was the primary text for Algebra 2 in the school before teachers created their own curriculum. The textbook, the Oklahoma edition of Glencoe McGraw-Hill's Algebra 2 (Carter, Cuevas, Day, Malloy, Casey, 2011), is a more traditional textbook; its stated aim is to backmap the full high school program, in order to ensure the program is "well articulated in their scope and sequence, ensuring that the content in each program provides a solid foundation for moving forward." (McGraw Hill, n.d.). For this lesson, only the student version of the lesson was supplied, which guided students through formal definitions and example problems. Thus, the lesson provided no teacher support.

Data Analysis

Each of the interviews and think aloud sessions were audio recorded and transcribed verbatim. Field notes were taken during observations during classes and individual and collaborative planning sessions. Research notes were taken as documents from the Google drive, as well as other documents voluntarily provided by the teachers during interviews and observations, were analyzed. Each resulting set of data was then subjected to coding and theming using a constant comparison method to systematically

identify themes as they emerged. Reader response theory and metacognition served as theoretical lenses as the data were analyzed. In particular, the data were examined for evidence of each of the participating teachers' purpose(s) for reading, identity and confidence and a reader of curriculum materials, ability to construct meaning from multiple perspectives, and metacognitive behaviors used while reading. After reviewing and coding all for the data, categories of data under each code were formed in order to answer the research questions (Merriam, 2009). Axial coding allowed the data from different sets to be compared and, ultimately, findings to emerge.

Findings

The processes used by the participating teachers to evoke and interpret meanings from curriculum materials were complex and recursive. They read curriculum materials not only to determine the potential of the curriculum materials, but also the feasibility. In fact, feasibility, in terms of time and resources needed, was generally the primary concern of the participating teachers; the participating teachers only began to focus on pedagogical approaches and mathematical content after the feasibility of the lesson, in terms of time and resources, had been established. Then, the potential of the curriculum material to engage students became the primary focus. As their purpose for reading the curriculum materials changed, the metacognitive strategies they employed to make meanings also changed; teacher largely used visualization and acting-out techniques to establish the feasibility and potential level of engagement of students, but tended to reread and use self-questioning techniques when focused on the mathematical content of the curriculum materials. Their interpretations of both the feasibility and potential of

the curriculum materials were greatly influenced by their confidence which, in turn, was influenced by the recent performance of their students.

Purposes of Reading

The data revealed that, when reading curriculum materials, each of the participating teachers had multiple purposes. All the participating teachers attempted to ascertain the feasibility of lesson presented in curriculum materials, in terms of resources and time. In addition, all the participating teachers were very concerned with how their students might react to or engage with the curriculum presented in the materials. Only after lessons were deemed both feasible and engaging were other aspects of the lesson materials examined. For example, after determining the feasibility and engagement level of lessons, several of the participating teachers focused on the opportunities to make connections between different topics within mathematics, between mathematics and other content areas, or to real-life applications. Only occasionally did the participating teachers directly address mathematical understanding while evaluating curriculum materials. When they did, it was usually an attempt to better understand the mathematical concepts themselves, rather than a consideration of what mathematical understandings students may or may not gain.

Reading for Feasibility

The first concern of all the participating teachers when reading curriculum materials was the time necessary to devote to the lesson; each of the participating teachers commented on the time needed to complete the lesson for each of the three lessons they reviewed for think-aloud sessions. Across the board, all the participating teachers quickly decided that the *Light it Up!* lesson plan from NCTM's *Illuminations*

was infeasible as written because of the time needed for it, which they estimated at three and five days. Based on this assessment, both Emily and Sarah stopped before they completed reading the lesson and only made further meaning from the lesson when prompted to reread each portion. Amanda and Jessica read the full lesson without prompting but, when asked to evaluate the lesson after reading it, responded that, while they believed the lesson would be meaningful, the length of the lesson made it infeasible as written; only Jennifer attempted to consider how to alter the lesson to make it more feasible:

> Ok, so I would look at that and go how many of [the included problem sets] do we actually need to do? Do we need to do them all? Do I pick two and deal with them? Do I do two with them and give them two to do and group them up?

On the other hand, all the participating teachers agreed that the lesson from Glencoe McGraw-Hill's *Algebra 2* would require the least amount of time to implement. Interestingly, however, Emily believed that this lesson would still require more time than the one day they currently devoted to the content: "if this were one lesson, it's kind of a lot. It would be too much to do all in one day." However, like the rest of the participating teachers, Emily agreed this lesson would take the least amount of time. Additionally, all the teachers stated that they would, under some circumstances, choose to implement it. For example, Amanda stated the lesson would be good to use "especially whenever you are having to get through this quickly. It gets the point across, but definitely, it's not something that screams oh, this is going to be a fun day in math." Likewise, the other teachers said they would use the lesson if they had limited time to address rational functions.

In addition to concerns about time, each teacher considered the feasibility of obtaining the materials required for the *Discovering Advanced Algebra* and *Light It Up!* activities (the lesson from Glencoe McGraw-Hill's *Algebra 2* required only materials used in the participating teachers' daily practices). For example, while Amanda made a point of noting that the spaghetti needed for the *Discovering Advanced Algebra* lesson plans was easily obtainable and cost effective, Emily noted that it must be an "old" lesson and questioned if she could obtain enough 35mm film canisters (which, in the lesson, were hung from spaghetti strands to hold weights) to implement the lesson. Similarly, Sarah wondered if the science department had mirrors she could borrow to implement the *Light It Up!* activity while Jennifer expressed that she believed the cost of laser pointers would make it prohibitively expensive to obtain enough to implement the activity. Jessica, on the other hand, wondered how she could find an unused space in her school large enough for all her students to construct the apparatus needed for the activity. Thus, all teachers were concerned with ensuring that they had the physical space and resources needed to implement lessons. However, unlike time constraints, when the teachers decided the lesson was infeasible as written because of the resources needed, all of them suggested ways to alter the lesson to make it more feasible and continue to make meaning from the lessons. Hence, teachers were more likely to be able to construct meanings from materials which, at first, seemed infeasible because of the required materials than they were from materials which seemed infeasible due to time constraints.

Reading for Engagement

Following concerns of feasibility, the next major concern for all the participating teachers was student engagement. Each teacher paid particular attention to the actions and processes students would engage in when evaluating curriculum materials. In interviews, Amanda stated that, when reviewing curriculum materials, she thinks "a lot about where my kids are and what we are talking about. If we've been sitting, doing notes, then let's get up, let's move, let's apply, let's collaborate." The participating teachers agreed that the *Light It Up!* lesson plan was the most engaging of the three lessons they reviewed in think aloud sessions because of the game at the core of the lesson. Emily and Amanda, in particular, seemed confident that any kind of game would be engaging to their students simply because it was a game, while Jennifer, Jessica, and Sarah stressed the hands-on aspects of the game.

However, some of the teachers felt that this lesson might be overwhelming for students and were hesitant to attempt it. They felt that students would cease to engage in lessons if they began to feel overwhelmed. Jennifer, Jessica, and Sarah believed the *Light it Up!* activity was likely to be overwhelming for students because of the amount of written materials included in the curriculum materials. Jessica insisted that the worksheets that were part of the lesson should be distributed one at a time, while Jennifer stated:

> At a glance, it's very wordy. So if I like, put a packet of this stapled in front of my students, they'd be like whoa, we're doing all this? So I feel like it would have to be little pieces at a time. Um, you know do you just give them this on a page and then do the question as a whole group as opposed to it being worded, bogged down with words. Because sometimes that scares them.

Likewise, Sarah stated that she would create her own, pared down, versions of the worksheets so as not to overwhelm students.

Amanda did not express any concern that the *Light It Up!* lesson would overwhelm her students. However, she felt that the lesson from Glencoe McGraw-Hill's *Algebra* 2 was more likely to overwhelm students. She believed the lesson was too technical and abstract in its presentation and summarized why she did not feel the lesson was appropriate for her students:

> Your kids who don't enjoy the traditional classroom, which unfortunately is many students, are just going to see a whole lot of variables and are really going to be overwhelmed…They're just cancelling things out, but they don't really understand why. Again, I mean it's kind of the monkey see, monkey do. I do a problem, you do a couple. Repeat.

All the teachers were concerned that the context in which lessons were delivered might make students feel overwhelmed, which might result in students disengaging from the lesson. Thus, determining the potential level of engagement, along with the feasibility of the lesson, was a major purpose for the teachers as they read and made meaning from the curriculum materials. However, unlike the feasibility of the lesson, which teachers were easily judged simply by scanning the lesson, each teacher closely read the lesson before judging its level of engagement. In addition, all the teachers expressed ideas about how to make the lesson more engaging or less overwhelming as they read.

When reviewing written curriculum materials, Emily evaluated the quality of curriculum based solely on their feasibility and engagement, though she noted that "you have to see it in action to really get it"; that is, she did not form complete meanings of

lessons until she enacted them. The remainder of the teachers, on the other hand, reread the lessons they felt were sufficiently engaging and feasible to make deeper meaning from the curriculum materials before implementing them. However, their specific purposes in rereading varied. For example, as Jessica reread, her thoughts focused on the ways in which applied problems were presented in the lessons. Referring to the lesson from the previously used textbook, she noted that many of the word problems presented in the lesson contained the equations which model the situations described in the problem. "I don't know where the equations come from. I could show my kids, but you don't know where it comes from. When they actually investigate things, they see where the equation comes from". Likewise, when the lesson plan for *Discovering Advanced Algebra* suggested giving students data to work with rather than having them collect their own data as a way to save time, Jessica responded negatively:

> This makes me sad 'You can use the sample data to conduct…' Well, if you're not going to conduct it, then just don't do it. Either get your own data or don't. Don't say, 'hey, if we pretended to do this…'. No, let the kids do it.

Sarah, on the other hand, looked for ways the lesson connected math to other content areas. She particularly liked the *Light It Up!* lesson because she saw a strong connection to light and the scientific concept of refraction, topics which her students were currently studying in their science classes. Amanda and Jennifer also looked for connections while rereading the lessons, but particularly looked for connections between different mathematical concepts. Amanda explained why she felt it was so important to focus on such connections:

> I think so often in math, we think of all thee thigs as separate ideas. This is the unit on solving. We're only going to solve for x. This is the unit on

> quadratics, we're only going to talk about quadratics. But really, math is patterns. It's seeing the connection, it's making sense of things. And if you don't teach them how to connect those things, they won't.

Reading for Conceptual Understanding

Occasionally, Amanda, Jessica and Jennifer also spent additional time reviewing the curriculum materials to better understand the mathematical concepts presented. In particular, Jennifer almost always reflected on her understanding of the concepts and purpose of the lesson before deciding on its quality. For example, after fully reviewing the *Light It Up!* activity, Jennifer summarized her understanding by asking herself "Ok, what did you learn?" and answering "rational functions are quotients of two functions in standard form. I think what's the purpose of this lesson- to see the relation, the real-world application of a rational function." If she was unable to summarize the purpose and main idea of the lesson, she would reread it again until she could.

Jessica, on the other hand, did not wait until the end of the lesson to determine if she understood the mathematical concepts, but paused at the end of each section of the lesson to reflect on her understanding. For example, when reviewing the lesson from Glencoe McGraw Hill's *Algebra 2*, Jessica realized her understanding of domain restrictions when dividing to quotients differed from the formal explanation in the book. The book stated "For all rational expressions a/b and c/d with $b \neq 0$, $c \neq 0$, $d \neq 0$" the quotient of a/b and c/d is equal to ad/bc (Carter, Cuevas, Day, Malloy, Casey, 2011, p. 555). When she read this explanation, Jessica responded that "they put that b cannot be zero, c cannot be zero, d cannot be zero, but b and c are the only ones that are in the bottom." She then reread the definition several times. Ultimately, however, she began to

read the next portion of the lesson without resolving the discrepancy in her understanding.

Neither Emily nor Amanda were observed focusing on their mathematical understanding while reviewing the written curriculum materials. Instead, during observations, they occasionally realized their mathematical understanding was wrong or incomplete while enacting lessons. When this happened, they either avoided the problem or example about which they were unsure, tabled the discussion for the next day, or sought advice, mostly from Jessica, who taught next door to Amanda and across the hall from Emily. Finally, Sarah was not observed having mathematical misunderstandings while reading curriculum materials or enacting the curriculum.

The findings, thus far, have mostly focused on the teachers' purposes for reading new curriculum materials, mainly in the context of think-aloud sessions. However, when reviewing curriculum materials already familiar to them, the purposes for which the teachers reviewed the material were largely the same. During observed collaborative planning sessions, the teachers would review the curriculum materials in their collective curriculum library. During these collaborative meetings, they would largely focus on issues of feasibility and engagement to determine a daily calendar for the unit. They considered how much time they could allot for the unit, how many lessons and activities they could include given the time allotted, and which lessons and activities were most likely to engage students. After these decisions were made, teachers then worked individually with the curriculum materials chosen for the unit. Just as discussed above, some reread the materials to determine what connections could be made within each lesson and between various lessons as well as to review the mathematical concepts

presented in the lesson. Jennifer and Jessica, the two most experienced teachers on the team, tended to engage the most in these individual processes, while Emily, the first-year teacher, engaged in them the least. However, the extent to which teacher made individual meanings from the curriculum material also depended on their individual level of professional confidence at the time.

Confidence

Each teacher's confidence level rose and fell multiple times throughout the course of the study. The ever-changing status of their confidence as readers of curriculum was perhaps most evident with Emily, who was a first-year teacher. Even in the best of times, in interviews, Emily made it clear that she did not feel fully confident to assess curriculum materials or design curriculum on her own. Instead, she felt "blessed" to have a collaborative team that would determine what curriculum materials she should use in her class. Indeed, not only were all lessons used by the team shared with Emily, but the rest of the team was observed making copies of materials and answer keys for Emily and giving her advice about what portions of lesson to emphasize, which portions students might find challenging, and even how to organize materials for her lessons. Even with the support, Emily's confidence was often challenged, including during a parent conference in which it was implied that the student in question was not being successful because of her. Directly after this conference, the Algebra 2 team held a planned collaborative meeting to discuss the guided inquiry unit they planned to enact for the first time. During the meeting, in tears, Emily stated that she was unsure if she really understood what was going on in the unit and questioned her ability to implement it, despite having been part of developing it.

However, by the time the unit was implemented, Emily's students had exceeded her expectations on a unit test, and Emily decided to implement the new unit.

Jennifer was also acutely impacted by her students' achievement on assessments. When students did not meet her expectations on assessments, she very explicitly questioned if their performance was due to something she did. When her confidence in her students' learning was shaken, Jennifer changed plans to reteach material. The lesson meant to reteach were solely focused on lecture and notes. In an interview directly following such a lesson, Jennifer explained that, because she needed to reteach, her time would be short, so she needed a lesson that "got right to it'.

Jessica's confidence was less dependent on her students' past performance, but instead depended on her ability to predict her students' performance in future lessons in terms of what concepts would be difficult for students and what questions students might generate. When reading lessons, she often attempted to predict both student difficulties and student questions. When she felt she could, she was more confident in her ability to make meaning from the curriculum materials, adapt them appropriately, and implement them in her class. For example, she had a very negative reaction to a portion of the *Discovering Advanced Algebra* lesson which applied rational functions to mixing chemicals. "I know they do that, they do some of that in chemistry and stuff and I… I don't think I'd be very good at explaining that. I know they like those problems, they're on the ACT and stuff, but I won't know how to answer their questions." When she reached points in lessons which posed difficulty for her, rather than attempt to make meaning from them, she instead thought of ways she could alter the lesson or complete an alternative activity for part of the lesson as to avoid the material which caused her

difficulty. However, in interviews, she also asserted that she is becoming more comfortable with uncertainty:

> Last year some question came up that some kid asked and I was like that's a great question! I never thought about it before, but I felt comfortable embracing it. I was like guys, what do you think? You know? And as they were thinking I was thinking and processing myself too, but that takes time too. Being comfortable letting go and letting them have that time to process and think through things.

Note, however, that this uncertainty arose while enacting the curriculum; thus, Jessica has developed comfort with uncertainty while enacting curriculum, but not while evaluating written curriculum. Amanda, too, was learning to maintain her confidence during times of uncertainty while enacting curriculum.

> This is the first year that I'm actually able to kind of go…oh, this is interesting, what do we think about that? Why? Where before, I wasn't sure if I understood why. Better yet, knew to pose that question at all. Letting them see that you don't have all the answers all of the time. As a brand new teacher, that's very hard, because you feel like you should be the loudest voice in the room and the smartest voice in the room. Because I mean, you're the teacher, that's, you're not supposed to not be able to answer the questions. And as you get more comfortable with your teaching, and just in your own skin, then it's ok to say, that is an excellent question, I don't know. Let's think about it.

The bigger challenge to Amanda's confidence was the master's level education courses she was taking. The courses made her question practically every aspect of her teaching during interviews. "Am I doing the right things? Am I doing it enough? I need steps, rules, but is that what my students need?" Because of these courses, Amanda incorporated more new curriculum materials into her classes than any of the other participating teachers. When the new lessons or activities went well, her confidence soared, and when they did not, her confidence fell significantly. As a result, her

approach to curriculum materials swung dramatically as well; when things were going well, she was excited to look for new ideas and approaches to try. When she was not feeling confident, she clung to the same structure she had used for lessons in previous years.

Sarah, on the other hand, enjoyed a fairly stable level of confidence, which afforded her a greater sense of freedom to experiment with new curriculum materials, or with her own adaptations of curriculum materials. During interviews, she said she believed much of this confidence stemmed from the fact that she saw each of her students two periods a day, once in Algebra 2 with Jennifer, and again in Algebra 2 Applications, which provided her special needs students with additional supports. Sarah believed the additional time allowed her to risk making mistakes; if a lesson did not meet her expectations, she retaught the lesson from a different perspective on another day in her Algebra 2 Applications class. Thus, Sarah often had a different view of the curriculum materials the teachers were asked to review; often, she quickly suggested alterations to lesson plans as she read. For example, the *Discovering Advanced Algebra* lesson opens with an application of adding weight to a tree branch at different locations along the branch to test how much weight the branch can hold at various locations. The lesson quickly explains that this relationship would be modelled by a rational function. However, Sarah suggested having students brainstorm about what the graphical representation might look like first. Additionally, while the mathematics educators saw the lesson from the Glencoe McGraw-Hill as usable when short on time but undesirable, Sarah saw the lesson as almost a blank slate around which she could create her own curriculum:

> You could do anything with this that you want, because you are given the material and you could tailor it to something that you wanted to do. Like add to it if you wanted to. You know, make a game of it or whatever. Have them work in groups. You would definitely need to add to it. This isn't enough on its own.

For all the teachers, their confidence level impacted their willingness to enact different meanings of lessons; when feeling most confident, teachers were more likely to experiment with lessons and push students out of comfort zones. The less confident they felt at a particular time, the more likely they were to utilize traditional lecture and note based lessons. In this way, their confidence impacted the meanings they could evoke from the curriculum materials.

Metacognitive Strategies Used to Make Multiple Meanings about Process

The participating teachers regularly used a variety of metacognitive strategies to help make meaning from curriculum materials. The most commonly used metacognitive strategies were those which allowed teachers to approach the curriculum materials from the perspective of the student; these included visualizing the lesson, acting out different portions of the lessons from the student perspective, and, ultimately, predicting students' reactions to the lesson. However, during observed collaborative planning sessions, individual planning sessions and think aloud sessions, teachers also sometimes reread curriculum materials and posed questions to themselves or others to clarify their meaning. When these strategies were utilized, the focus typically shifted from students to content. That is, while visualizing, acting, and predicting were used to ascertain the student perspective, rereading and questing techniques were used to interrogate the mathematical content.

As teachers began to read curriculum materials, they first attempted to visualize the lesson. For example, when evaluating the *Light It Up!* activity, Jennifer spent significant time moving her hands and objects on the desk around until she could visualize the experiment students would set up as part of the lesson, referencing a diagram given in the lesson as she did.

> So they're going to sit there and just move it back and forth until they can hit it and kind of come up with their equations from there. (*Reading*) "Plot distance from the wall to the laser pointer" So that's just where you are standing, ok. What's the distance from the light… floor to the mirror? Here? No, there's the mirror (*points to diagram).* The distance from the wall to the center of the mirror would be this (*points to diagram*).

While the other teachers did not necessarily model the lessons with physical objects, each of them sought to understand what they lesson might look like as it was being enacted. They thought about how to place desks in their room for students, where and how to organize and set up materials, and what different member of a group might be doing at different times throughout the lesson. At various times, some of the teachers felt the need to complete portions of the lesson from the perspective of the student. Jennifer simply commented that she would need to do the work herself if she were going to implement the lesson, while Amanda and Emily felt the need to do the work of the student as they read the lesson. For example, when Emily reviewed the *Discovering Advanced Algebra* lesson, she asked if he could complete one of the exercises presented, explaining:

> I'm starting to understand it but I, and I think it would be better if I went through it myself, just like if I went through this one for myself, it would obviously be better and I would understand it, exactly what it's wanting, what my kids would need to do.

In other words, the teachers used visualization and placed themselves in the role of the learner to understand the lesson from the perspective of the students. Based on the results of these exercises, the teachers then often predicted how groups of students or individual students would react to the lesson; which students or classes would be interested in the topic, at what point classes or particular students were likely to go off topic, and what parts of the lesson students might find challenging. Thus, the teachers sought to make meaning from the perspective of the students. For example, Jennifer considered how a typical student in each of her Algebra 2 sections would respond to the lessons. She explained that it was important that the sections of Algebra 2 she team taught with Sarah "feel some confidence, you know, some of them are coming from intermediate algebra, some are coming from geometry. We just want them, I want them to feel 'I can do this'" while for another class she focused on being able "to push the bar a little bit. Ask them well, like, why? How is this going to work? And try to get them to discover things more than just me explaining it all." In addition to considering different classes, Sarah also considered how she might have responded to the lesson while in high school. In interviews, she explained that she had difficulties in mathematics at that age, which helped her to predict what difficulties her students might have. She felt that recalling how she made sense of the content in high school helped her predict how well students would succeed with different lessons. In contrast, during interviews Amanda explained that as she read curriculum materials she tried to keep three particular students in mind. The particular students changed, but she always chose to consider a student performing above, at, and below her expectations and consider how they would perceive the lesson. She felt that it was important that each lesson engaged each of these

students. Emily and Jessica made meaning from the perspectives of students as well; sometimes they considered whole classes, while at others they considered individual students or reflected on their own learning as a student. Thus, all the teachers attempted to make meaning from multiple student perspectives by visualizing and engaging in the lesson from the perspective of the students.

It is important to note that, during observed lessons, the teachers continued to create multiple meanings as they enacted their lesson plans. Each teacher routinely made decisions during the lesson that altered the lesson from the written plan. For example, each of the participating teachers were observed adding and deleting examples throughout lessons. Sometimes, these changes were made after asking their students if they wanted another example, if they were feeling comfortable, or if they were ready for something new. At other times, teachers expressed that these changes were made based on their observations of students work or body language, or simply due to time constraints. Even as they read the curriculum materials, each one commented that, as Jennifer put it "You never really know how a lesson will go until you try it." In other words, the teachers never felt that they had a completed understanding of curriculum materials until they implemented a lesson based on those materials.

Metacognitive Strategies Used to Make Meaning of Mathematics

Sometimes teachers were observed making decisions while enacting curriculum not based on their students, but because they realized that their own understanding of the mathematics being presented was incomplete; usually, this occurred because they had not attempted to make sense of the mathematical content in a lesson when reviewing it. If, and when, teachers did begin to consider the mathematical content of

the written curriculum materials, either of their own accord or because they were prompted, they began by rereading the curriculum materials. While rereading, their attention turned to what mathematics was being addressed in the lesson and what content they believed was or was not well addressed. Sometimes, the teacher felt the need to read sections a third or even fourth time if the mathematical content confused them. For example, after reading the *Light it Up!* lesson from NCTM's *Illuminations* for the second time, Jessica commented "Ok, I think we're talking about like, the direct and inverse variations sort of things, and how they relate to rationals." She then reread different parts of the lesson again, summarizing the purpose of each portion of the lesson before moving onto the next: "So this part makes it move left and right…that part makes it move up and down…I got that part." Finally, she reread the entire lesson a fourth time: "Right now I'm just kind of reading through again and I'm like ok, this makes sense. So, they are wanting to tie all this together. Umm, and like pausing at certain points for discussion." Thus, it was only during fourth reading that Jessica began to make connections between the content presented, which she had made sense of during the second and third reading, and the overall structure of the lesson. In addition, it was after the fourth reading that she began to compare the lesson to her typical lesson on the same concepts.

> I like this part here where they are talking about…talk about the graph and the problem context and relating it to a, b, and c. Because like I said, the shifting left and right, we never do a very good job of explaining why. Like even how it relates to the table almost. It's kind of just like hey, it's the left and right an it's opposite, we see that, ok, cool. Check. Move on.

However, of the three lessons Jessica reviewed during think-aloud sessions, the *Light it Up!* activity is the only one Jessica read four times and the only one for which she reflected on both the pedagogy and content, even after prompting.

Only Jennifer, the most experienced teacher, routinely reread to make sense of the mathematics without prompting. The four other participating teachers also found it necessary to reread to make sense of the mathematics in each lesson, but, aside from the Jessica when reviewing the *Light It Up!* lesson, only did so when prompted. As they reread, however, they began to use self-questioning to make meaning. For example, when rereading the *Light It Up!* lesson plan, the teachers asked themselves the questions in Table 6.

Table 6. Questions Generated by the Participating Teachers

Teacher Pseudonym	Questions
Jennifer	What is the relationship between the number of people who go on the trip and the cost per person? How does this [coefficient] effect [the equation]? So you sketch your graph and then come up with the line of best fit essentially? The curve of best fit? Is the 'a' value supposed to be one the whole time?
Jessica	Are they talking about the direct and inverse variations sort of things? How do they relate to rationals? How are they connecting it to the equation?
Sarah	How are [the two graphs] the same? How are they different? So they would have to move the graph based on the constant? What is the range of the function?
Amanda	What are we given? How do we investigate that? How does the graph shift in this one?
Emily	How could we write a rational function? Where are the vertical asymptotes, how do we find that? What does 'a' do, what does 'b' do, what does 'c' do?

When asking themselves these questions, the teachers were attempting to make sense of the mathematics in the context of the lesson. In other words, it was clear these teachers understood transformations, asymptotes, graphs, and the result of the concepts presented in the lesson. However, they were asking these questions to ensure that they understood how these concepts were being applied in the lesson. Thus, the teachers focused on issues of context. Their meaning making began with making sense of the lesson in terms of the time and resources they had available, continued by considering how the lesson was situated within broader contexts in terms of the connections the lesson made to other mathematical content, content in other student courses, or real-world applications, and ended with investigating the mathematical understandings explored within the context of the lesson itself.

Discussion

The findings of this study demonstrate the highly recursive nature of teachers' meaning making from curriculum materials. Teachers tended to read curriculum materials multiple times for different purposes, thus creating multiple meanings. Multiple meanings were made from the perspectives of students; either with a 'general' student in mind, specific students in mind, or from the teachers' perspective of themselves as a student in mind. However, both the purposes and perspectives with which the teachers read the curriculum materials also constrained the meanings they made. If the curriculum materials were deemed by the teachers to be infeasible or unengaging during the first reading, they often did not read the materials a second time to discern what connections or mathematical meanings could be made. Thus, Brown's contention that teachers can only interpret meaning based on students and context after

meanings are made, while true, oversimplifies the process and overlooks the role of students and context in constraining the meanings made as well (M. Brown, 2009).

These findings also support the claim that teachers' ability to make meaning with curriculum materials develop with experience because they are more able to predict students' needs and responses to curriculum materials (Ben-Peretz, 1990). Indeed, the participating teachers, especially those with more experience, were aware of the role experience played in meaning making. As Jessica said, "that takes time. I think every year you teach it you think about more of those concepts that you want to drive home. You think about where those concepts come in. You think about how those concepts made sense to students before." However, the dominance of meaning making from students' perspective may be problematic in two ways. First, relying on student perception may constrain the ability of the teacher to change pedagogical approaches; students are likely to be more comfortable with approaches with which they are already familiar, and thus may be perceived to be more likely to engage in lessons which use familiar approaches. Second, we would hope that teachers use pedagogical knowledge to facilitate meaning making, but aside from the focus on students' engagement and connectedness with the materials, the participating teachers used very little pedagogical knowledge to make sense of the curriculum materials; there were very few times that the participating teachers overtly attended to issues of quality teaching practices or mathematical standards of practice identified by the National Council of Teachers of Mathematics, the state standards, or other professional guidelines. That is, they did not explicitly consider the concepts of productive struggle, modeling and conjectures, or problem solving when making meaning from the students' perspective, nor did they

consider goal setting, purposeful questioning, or eliciting evidence of student thinking when reviewing material for other purposes, though it can be argued that some, if not all, of these concepts were implicitly included in their thoughts on engagement and connectedness.

Confidence also influenced teachers' abilities to make meaning from the curriculum materials. Though their level of confidence was influenced in a variety of ways, it was most clearly impacted by the achievement of their students; it is clear that the participating teachers have internalized the assertion, central to the age of accountability in schools, that student performance is the sole responsibility of the teacher. Thus, when students did not perform to expectations, teachers' confidence was impacted in clear and negative ways which resulted in the teachers returning to traditional lecture and notes based lessons. At these times, they were less willing to implement lessons which used other pedagogical approaches, regardless of the teacher's belief about the quality or effectiveness of such approaches. Even when feeling their most confident, the participating teachers rarely questioned the sequencing or themes of curriculum material, but rather focused on choosing appropriate activities and emphasis for the lesson. These findings parallel those reported by Ben-Peretz when investigating teachers' use of textbooks. However, Ben-Peretz assumed the reticence to address themes and sequences was a result of the use of a single textbook, believing that teachers hesitated to diverge from the overarching structure of the year-long curriculum presented within the textbook (Ben-Peretz, 1990). However, even as these teachers moved away from the use of a single textbook, they remained committed to the overarching structure that had been derived from the previously used textbook

despite much of their materials being from other sources. This illustrates the teachers' perceptions of themselves as curriculum users rather than curriculum designers; they read to determine the best use of curriculum materials, but did not address how curriculum materials related to each other.

It is interesting to note that these teachers employed different metacognitive strategies to support their meaning making as they read curriculum materials for different purposes; they visualized and acted out parts to make meaning from the perspective of a students while they re-read and questioned themselves to make meaning of the way in which the mathematics was presented. This may have broad implications for professional development and teacher education. Why do teachers use only a select few metacognitive strategies for the various purposes; are these strategies simply the most appropriate strategies to use, or are their other metacognitive strategies the teachers have either not developed or not realized may be useful in this context? Further study is needed both on what meta-cognitive strategies teachers use for what purpose when transacting with curriculum material as well as what metacognitive strategies *could* be used to make multiple meanings for various purposes. Additionally, how teacher education, professional development programs, and curriculum materials themselves can facilitate the development and use of these metacognitive strategies needs further study.

Finally, while the predominance of the use of student perspectives to make meaning from curriculum materials raises serious questions, it also served as a marker of progress; clearly, the teachers who participated in this study, consciously or unconsciously, thoroughly subscribe to sociocultural learning theories that place the

student at the center of education (Stinson & Bullock, 2012). Their ability to, and insistence on, making meaning from the perspective of students speaks to their "imaginative capacity to put themselves in the place of others - a capacity essential in a democracy, where we need to rise above narrow self-interest and envision the broader human consequences" (Rosenblatt, 2005, p. xxxiii). This skill is an important precursor to developing mathematics curriculum that is truly responsive to students needs and interests and prepares students well for a society changing at an increasing pace, both in terms of technology and social development. What is needed next is the ability to make deeper meanings from the perspective of a pedagogical expert, and the ability to synthesize meanings made from both the student and expert perspectives. This ability is especially vital when viewing meaning making as a transactional system in which not only teachers, students, and curriculum materials work in tandem to create meaning, but in which local contexts also work to shape curriculum. Teachers must be able to understand how curriculum can be shaped by each of the aspects in the system and work to synthesize the meaning to allow a coherent curriculum to emerge.

Chapter 4: Physical Space and Professional Place: Constraints on Meaning-Making for Algebra 2 Teachers

Understanding the relationships between curriculum materials, teachers, and the curriculum is increasingly important. Teachers are beginning to turn to the textbook less often, and draw on a variety of other publications or self-created materials more often (Ben-Peretz, 1990; Chval, Chavez, Reys, & Tarr, 2009). As the popularity of textbooks decreases, the prevalence and popularity of Internet-based lesson resources and exchanges are increasing. (Abramovich, 2013; Drijvers, 2015). The vast majority of teachers now select at least some of their curriculum materials themselves (Larson, 2016). According to a study by The Education Development Center, almost half of teachers in STEM content areas routinely search for curriculum materials online (Abramovich, 2013). The availability of extensive online resources has fundamentally changed the ways in which teachers interact with curriculum materials. Before this technology, the quality of curriculum resources teachers encountered was controlled by publishing companies and district supervisors; the availability of Internet-based teacher resources reduces these control factors (Abramovich, 2013). This greatly increases the chances that curriculum coherence is lost as teachers adapt materials from a wide variety of sources and as students move between teachers who utilize different curriculum materials (Larson, 2016). That is, by using multiple sources created for multiple purposes by multiple people, teachers risk failing to create a curriculum that develops "important mathematics along coherent learning progressions" (NCTM, 2014). If teachers are to create their own coherent curriculum, teachers must be able to make meaningful connections between a variety of curriculum materials. Their ability

to do so rests in their ability to make multiple meanings from curriculum materials, so that they may choose the most appropriate meanings for their curriculum.

Some researchers studying the use of curriculum materials now utilize reader response theory, which assumes that the perceiver and the perceived are both aspects of a system of meaning making, to describe the process of developing curriculum from curriculum materials. Reader response theory has emerged from transactional theory, which claims that that meaning-making is a transactional system in which meaning emerges from the transactions between the text and the reader (Rosenblatt, 1978). Further, both transactional and reader response theory suggests that meanings made can be influenced and constrained by the context in which the text is read. (Remillard, 2005; Rosenblatt, 1978). Thus, it is important to examine how context can influence and constrain the meaning-making of teachers.

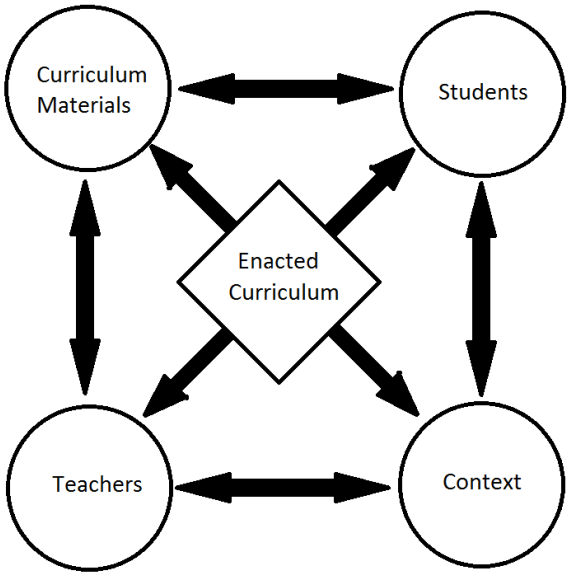
Influences on Meaning-Making

There are many factors which influence teachers' meaning-making from curriculum materials. For example, the needs and abilities of students, time constraints, social and cultural factors, and support provided to teachers have all been shown to be influences on the curriculum (Ben-Peretz, 1990; Lloyd et al., 2009; Remillard, 2000, 2005). Many theories have emerged which explain the relationship between these factors and teachers' meaning making. For example, enactment theory (Cho, 1998; Snyder et al., 1992) posits that teachers' and students' uses of curriculum materials impact each other and that, in this way, teachers and students work together to make meaning of the curriculum materials. Thus, students influence the use of curriculum materials as well as teachers' perceptions of their students. Other theories that examine

the modes in which teachers engage with curriculum materials describe teachers' actions as collaborating or participating with curriculum materials in order to construct the intended curriculum (McClain et al., 2009; Remillard, 2005). Proponents of these theories seek to understand the transactions of the teacher and the text and accepts that it is influenced by not only teacher beliefs and knowledge, but the context in which they teach as well. Additionally, these theories claim that teachers' stances towards curriculum materials, that is, their purpose in reading, also impacts the meaning made from the curriculum materials (Remillard, 2015).

Taken together, enactment, reader response, and modes of engagement theories can be thought of as emphasizing different aspects of a larger transactional system in which curriculum materials, teachers, students, and context work together and through each other to enact curriculum. In a transactional system as described by Dewey and Bentley, aspects continually act on, and are acted upon, by the other aspects of the system. Therefore, transactional systems can only be understood by studying the system in its entirety. In other words, no single aspect can be fully understood without examining the ways in which the other aspects of the system transact with it (Dewey & Bentley, 1949).

Figure 6. Transactional System of Curriculum Meaning Making



This use of the term transactional should not be confused with the use of the same word when discussing transactional leadership, a theory of leadership first defined by Max Weber and further developed by Bernard M. Bass. Transactional leadership describes a method of leadership which is focused on giving rewards for defined and expected behavior and is focused on using regulation, control, and obedience (Bass, 1995; Nikezic, Puric, & Puric, 2012). In other words, this theory utilizes the definition of transaction as "an exchange or transfer of goods, services, or funds". In Dewey and Bentley's description of a transactional system, the word transaction is used to denote a system in which each aspect acts on and through the other aspects of the system (Dewey & Bentley, 1949). In other words, Dewey and Bentley sought to emphasize the reciprocal nature of aspects in a system.

The concept of a transactional system was foundational in Rosenblatt's transactional theory, on which much of reader-response theory relies. According to Rosenblatt's transactional theory, when a text is read the aspects of a transactional system (including the reader, the text, and the context) work interobjectively to create

meaning. In other words, each aspect acts with and through the other aspects in order to create meaning (Rosenblatt, 1978). The theory relies on the concept of a stance towards a text as discussed above. Thus, theories about teachers' modes of engagement explicitly rely on transactional theory.

From the perspective of transactional theory, the enacted curriculum can be viewed as the meanings made from a transactional system that consists of curriculum materials as texts, teachers and students as readers (both of the text and of each other) and local school structures, cultures, policies, and procedures as context. Thus, the relationship between teachers and curriculum materials is just one aspect of the larger transactional system of curriculum implementation. Therefore, analysis of the transactional curriculum system must seek to illuminate how each aspect of this transactional system influences the others.

Influences on Meaning-Making

A view of curriculum implementation as a transactional system requires the consideration of a host of questions about how each aspect acts with and through the other aspects of the system. Studies have found that a myriad of factors influence how teachers use curriculum materials. Among the greatest influences are characteristics of the teachers themselves (Remillard, 2000). For example, Brown identifies teachers' knowledge and beliefs as the primary influences on their use of curriculum (M. Brown, 2009). Others have also included teachers' professional identity and experiences (M. Brown, 2009; Lloyd & Pitts-Bannister, 2010; Remillard, 2005; Remillard & Bryans, 2004). Below, some of the influences on the meaning-making of teachers are discussed.

Teachers' Knowledge and Beliefs

Mathematics teachers call on three types of knowledge as they use and adapt curriculum materials: content knowledge (knowledge of the subject), pedagogical knowledge (knowledge of teaching), and pedagogical content knowledge (pedagogical knowledge particular to the specific content being taught) (Shulman, 1986, 1987). Pedagogical content knowledge includes knowledge of those topics most regularly taught within the content, and different ways those topics can be usefully represented, explained and or demonstrated to students and is determined both by research and experience (Ben-Peretz, 1990; Shulman, 1986). This knowledge becomes even more critical in constructivist, inquiry focused classrooms in which teachers are expected to respond to the constructions and understandings of students (Shulman, 1987). Without this knowledge, teachers are unable to determine the ways in which curriculum materials could be adapted.

It should be noted that, within the literature, there is some disagreement about the difference between knowledge and beliefs. In general, however, knowledge is considered a subset of beliefs that have been justified and are held with certainty (Philipp, 2007). Thus, a given understanding can be considered knowledge for one teacher and a belief of another. For example, consider teachers' knowledge or beliefs about the nature of mathematics itself; whether they understand mathematics as a dynamic process of problem solving, or as a static body know knowledge consisting of proven rules and relationships (Felbrich et al., 2012). Some contend that this is knowledge and is the "greatest influence" on how teachers implemented mathematics curriculum (Manouchehri & Goodman, 2000). Other sources have categorized teachers

understandings of the nature of mathematics as a belief (Sawyer, 2014). While these studies do not claim that this belief is the greatest influence on the implemented curriculum, researchers generally agree that it does affect the intended curriculum. For example, teachers that view mathematics as static and rule driven have been shown to spend significantly less time planning and preparing mathematics lessons than those who view mathematics as dynamic problem solving (A. Thompson, 1984). This may indicate that these teachers spend less time considering ways in which the curriculum can be adapted.

It is not just teachers' beliefs about the nature of mathematics that influence their use of curriculum materials. Teachers' beliefs about the nature of teaching also have a significant impact (A. Thompson, 1984). For example, if teachers see themselves as facilitators, they may spend more time anticipating student responses or potential difficulties than those teachers who see their role primarily as a conduit of information (Remillard & Bryans, 2004). Teachers' beliefs about the purpose of schooling and the nature or quality of various reform movements have also been shown to influence teachers' use of curriculum materials (Usiskin, 2010).

It is important to note that teacher belief structures are not static; as teachers work with materials and reflect on the curriculum they have enacted, their belief structure may change. This may cause teachers to struggle in evaluating different curriculum materials and determining how best to use them in their classrooms (Remillard, 2000; Usiskin, 2010). Additionally, the beliefs that teachers hold may be consciously or unconsciously held, thus complicating teachers' ability to understand, or

at least articulate, the reasons they use particular curriculum materials in particular ways (A. Thompson, 1984).

Context and Meaning-Making

Both transactional theory and reader response theory suggest that context influences meaning making. Studies have shown that students who perceive their classroom environment to be supportive and engaging are both more motivated to make meaning from text and more resilient in their meaning-making attempts (Chou, Cheng, & Cheng, 2016; Padrón, Waxman, & Lee, 2014). While these studies show links between context and meaning-making for students, a search of an instructional database and ERIC revealed no studies of how context impacts the meaning-making of teachers. Thus, it is important to ask how context influence the meaning-making of teachers. This case study addresses this question by critically examining how the school context of five secondary mathematics teachers influenced their meaning-making during the Spring 2017 semester. Findings indicate that, although the context impacted each teacher in unique ways, both the physical space in which they taught (and anticipated teaching) and their professional identity (as perceived by themselves and by their administrators) worked to constrain teachers' meaning-making ability. Additionally, these two contextual influences were intertwined; that is, teachers' perceptions of their professional identity often depended upon the physical space in which they worked, and teachers attempted to create a physical environment that reflected their professional identity.

Methodology

This study sought to "*understand* how people make sense of their lives and experiences" from the perspective of the participating teachers (Merriam, 2009, pp. 23–24). As such, it utilized a case study methodology to investigate how context influenced the meaning-making of five Algebra 2 teachers in a suburban southern plains high school. Case studies are meant to focus on a particular situation, describe it in rich detail, and illuminate "previously unknown relationships and variables" (Merriam, 2009, pp. 43–44). During this case study, I sought to illustrate how context influenced the meaning-making of the participating teachers. The participants' context was dramatically changing during the Spring 2017 semester, in which the study was conducted. Not only were the teachers adopting new state standards for their courses, but the district in which they worked was preparing for a one-to-one technology initiative which would issue laptops to each student in the Fall 2017 semester. Thus, during the Spring 2017 semester, professional development and departmental meeting time was largely devoted to discussing how this initiative would and should change teaching and learning in the school. In addition, the school was undergoing physical renovations and expansions; thus, the physical characteristics of the school were undergoing dramatic changes. Hence, the case was bound in time, and focused on how the meaning-making of the participating teachers changed in response to changes in their context. Data were collected through interviews, observations, and documents. These data were analyzed using an interpretive perspective that sought to understand how each participant constructs meaning, conscious that the meaning-making process of

each teacher may differ significantly and depend upon the specific context in which each participant practices (Merriam, 2009).

The Case: Participants and Setting

The participants in this study, four mathematics educators and one special educator who co-teaches Algebra 2 with one of the mathematics educators, are the only Algebra 2 teachers in their school. I came to know these teachers through my work as a field supervisor for student interns. Two of the mathematics educators are midcareer and have been mentor teachers for student interns I have supervised; one of them recently won a highly selective award for their efforts in teaching, the other began her career as an alternatively certified teacher. The two early career mathematics educators were interns under my supervision who now work at the high school. At the time of the study, one was in her third year of teaching while the other was a true novice teacher, having completed her student teacher internship the previous academic year. The special educator, with whom I had no previous relationship, was new to the school but had previously taught in another high school in the district. Table 7 summaries the educational background and experience of the participating teachers.

Table 7: Participants' Certification, Education, and Experience

Pseudonym	Certifications	Degree(s)	Previous Years of Teaching Experience
Jennifer	Traditional Certification Secondary Mathematics	B.A. Math Education	11
Jessica	Alternative Certification Secondary Mathematics	B.A. Mathematics M.A. Mathematics	8
Sarah	Alternative Certification Special Education	B.A. Psychology M.A. Special Education	5
Amanda	Traditional Certification	B.A. Math Education*	2

	Secondary Mathematics		
Emily	Traditional Certification Secondary Mathematics	B.A. Math Education	0

**Amanda began a M.A. in Mathematics Education in the summer of 2016*

Each teacher has expressed the desire to continuously innovate in their classrooms. Theses teachers work closely with each other when planning for their Algebra 2 classes. Their desire to innovate and their culture of working and planning together may mean that these teachers engage in meaning-making from curriculum materials on a routine basis. Thus, there were significant opportunities to observe the meaning-making process of each teacher. Three of the teachers, Emily, Jessica, and Jennifer, had participated in a summer professional development workshop during which they created a guided inquiry unit that they planned to implement towards the end of the 2016-2017 school year. Because these teachers worked collaboratively, it was expected that Amanda and Sarah would also implement the unit. Thus, the teachers devoted two collaborative planning sessions to making meaning from the curriculum materials that had been created for the unit. These two planning sessions proved an invaluable source of data for this study, particularly about how the local context influenced their meaning-making decisions.

The school in which they teach is in a suburban town in Oklahoma. The high school has a history of excellence in mathematics teachers; multiple teachers in the mathematics department have received district, state, and national recognition for their teaching. The student body, approximately two thousand students, is largely white, with significant Hispanic, Black, and Native American Populations (Oklahoma Office of Educational Quality and Accountability, 2015). Though the average household income

is significantly above state averages, almost half of the students are eligible for free and reduced meals and poverty and unemployment rates are consistent with state averages (Oklahoma Office of Educational Quality and Accountability, 2015). Thus, there is a fair amount of income inequality among the students at the school.

Each of the participants taught multiple sections of Algebra 2, as well as sections of other courses such as Geometry, Math Analysis, Advanced Placement Calculus and, in the case of the special educator, Algebra 2 Applications, a course designed to support special needs students in Algebra 2. Algebra 2 is the highest-level mathematics students must complete to graduate. As such, all students in the high school take Algebra 2 and classes may have students of multiple ages, grade levels, and previous experiences in mathematics.

Data Collection

Qualitative research depends on the use of multiple sources of data so that the situation under investigation can be viewed from multiple perspectives (Yin, 2011). After obtaining informed consent of the participants, semi-structured interviews were used to collect demographic data as well as the participating teachers' beliefs, knowledge, and values about mathematics, teaching, and learning. Semi-structured interviews use both structured, pre-constructed questions and informal open ended questions (Merriam, 2009). Investigating teachers' beliefs, knowledge, and values was particularly important in this study because of the influence they had on the teachers' perception of their context.

Teachers were observed both during classes and planning periods throughout the Spring 2017 semester. As noted above, the participants often planned lessons together;

these collaborative planning sessions were also observed. Planning sessions were observed to examine how context influenced teachers' meaning-making from written curriculum materials; classes were observed to examine how the context influenced teacher meaning-making as they enacted the curriculum. In both individual and collaborative sessions, all the participating teachers relied almost solely on materials found in a digital curriculum library created by the teachers of Algebra 2 (some of whom had changed) at the school over the previous five years.

Notes made by the teacher on or about the curriculum material were collected when appropriate and non-disruptive to the teachers' practices and copies of the curriculum materials enacted by the teachers were collected to investigate characteristics of and commonalities among the curriculum materials that teachers choose to implement. These materials were coded and themed along with the interviews and observations.

Data Analysis

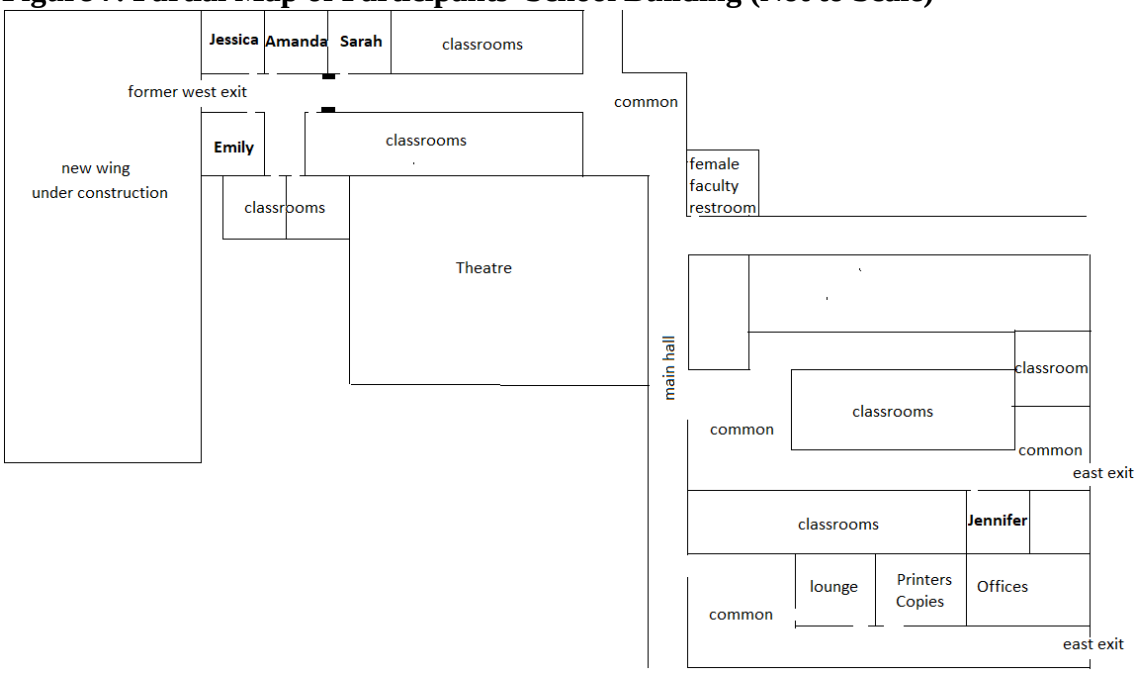
A constant comparative analysis method was used to systematically identify themes within the data as they emerged. The goal of the data analysis was to identify how the meaning-making of the participating teachers changed as the context in which they were teaching changed to illustrate the influence of context on the meaning-making process. However, because this study was qualitative and interpretive, as data were collected, the way in which the data were analyzed changed in response (Schwandt, 2015). As will be discussed, it became clear that it was not only important to examine the influence of the current context of the teachers, but also the anticipated future contexts in which the participants believe they will teach. This was necessary because

the participating teachers viewed meaning-making as an activity not done in a specific moment, but through a recursive cycle of reading and making meaning from curriculum materials, interpreting and enacting curriculum, reflecting on experience, and revising meanings. Thus, when making meaning, they did not simply consider their current context, but also how their context was likely to change.

The Big Picture of Context

To understand context, I must begin by describing the physical space in which the participants worked. Not only the physical environment of each classroom, but the placement of each room in relation to each other as well as other important locations in the school as these relations influenced the meanings made by teachers. Figure two gives an approximate layout of the school building and indicates the position of some of the locations that will be of importance in the findings about the participants.

Figure 7. Partial Map of Participants' School Building (Not to Scale)



Note that, in addition to the new wing being constructed, the common areas marked on the diagram were also undergoing renovations to create collaborative workspaces for students. These collaborative workspaces were meant to facilitate changes in the school structure, including the one-to-one technology initiative and a new freshman academy for the following year. At various times throughout the semester, each of these common areas was a construction zone. Similarly, the meaning-making processes used by the teachers were reconstructed throughout the semester in response to changes in the context around them.

Anticipating Changes in Context: The One-to-One Technology Initiative

The one-to-one technology initiative seemed to be ever present on each of the participants' minds. While the participating teachers were all comfortable and confident in their ability to use technology in the classroom, classroom use tended to be teacher-centered. That is, the teachers would use technology to display images or conduct demonstrations while students passively watched. While each teacher had a class website and used apps to keep students informed of upcoming assignments or assessments, these technologies were used outside of class time. The one-to-one initiative would place a MacBook in the hands of each students, and the administration clearly expected teachers to have students use these during class time. Though this initiative would not be enacted until Fall of 2017, it was a regular topic of conversation among the Algebra 2 teachers, who were already trying to make meaning of this new initiative, as Amanda explained in January:

> We're trying to figure out how that's going to look in a math classroom. We're still trying to figure that out, how we can incorporate that in; possibly with online homework, possibly not, we don't really know yet.

> But kind of thinking about how we can design our homework to use the technology but also be beneficial for the students.

As teachers planned collaboratively and independently, they often looked to make new meanings not just for their use in their current classes, but also to use in their future classes once the one-to-one technology initiative was in place. In April, they utilized the new guided inquiry unit they had developed the previous summer to experiment with integrating technology. Much of the framework required students to conduct their own investigation, which the participating teacher viewed as a natural opportunity to have students use internet technology.

However, they soon realized that the school did not have enough class sets of laptops for each teacher to check out one at the same time. After this realization was made, each teacher polled their class to see how many students had their own device they could bring to class with them. Based on these class polls, each teacher was confident that they could group the students in their classes so that each group had at least one member willing to bring in an internet capable device. As a group, they then proceeded to integrate online quizzes and surveys as well as the use of google docs for collaborative writing into the plan for the guided inquiry unit. Jennifer said she felt that this was "a nice way to test how the technology might work, since we are doing something new anyway."

The results were mixed, at best. The internet technology infrastructure at the school had not yet been upgraded when the guided inquiry unit was implemented in April. Even though each class only used one internet capable device per group, students found that downloads lagged considerably, much to the teachers' frustration, especially when Amanda, Jessica, and Jennifer were all teaching Algebra 2 at the same time.

Because of these difficulties, the teachers decided collaboratively not to integrate technology into their next unit, for which they were also adopting new materials that Amanda had developed as part of a graduate course. In other words, because they deemed their first experiment with technology unsuccessful, they chose not to continue incorporating technology into their lessons. This prevented them from making further meanings about how the one-to-one initiative would impact their practice.

Individual Contexts

While the one-to-one technology initiative acted as both a constraint on and a lens with which to make meaning for all the participating teachers throughout the semester, other changes in context impacted the meaning-making of the participating teachers in unique ways. Thus, the remainder of the findings focus on each participant in turn and focus on how changes in their context influenced the meanings they made of curriculum. These findings will then be synthesized, compared, and contrasted in the discussion.

The findings presented below tell the story of each participant's attempts not to make meaning not only of the curriculum, but of their profession, school, district, and place within each. These meanings were both significantly interdependent and significantly personal to each participant. The findings capture the complex and dynamic relationship between the participants' contexts and their ability to make meaning. Though context influenced each participant in diverse ways, two key aspects greatly influenced the meaning-making process of each teacher: the physical space in which they worked, and their professional place. By professional place, I mean not only their own identity as a teacher, but also how they were perceived (or how they believed

they were perceived) by others. Each participant identified as both part of an Algebra 2 professional community, and as part of the larger school community; the roles and responsibilities, real and perceived, placed upon participants by these larger communities influenced teachers' abilities to make meaning.

Jennifer: Orchestrating Meaning

Jennifer was the mathematics department chair and an award-winning teacher. She was considered one of the teacher leaders in her school, and was often tasked with additional duties because, in her words, the administration "knows they can rely on me". Because the room she had been occupying was slated to be renovated as part of the school's bond-funded construction project, Jennifer moved into a new classroom in Fall 2016. However, by Spring 2017, the classroom clearly reflected Jennifer. A graphing calculator caddy was hung on the right wall along with movie posters. At the back of that wall, photographs of Jennifer's family were arranged around a plaque which read "Teacher: To the world you are one person, but to one person you might be the world". The front wall had whiteboards mounted on either side of a large television screen connected to Jennifer's computer; an upgrade to the interactive white boards which were installed in most of the other classrooms in the building about which Jennifer felt ambivalent. While the video quality and capability were improved, she was no longer able to write directly on the screen as she had been able to with the interactive white board. Instead, she had to use a mobile device to write on the display. While she was used to using the device, she said the connection sometimes failed, leaving her without any ability to write on the display. The newly renovated classroom in which she was place did not have any traditional whiteboard installed for the first month of school,

which made the unreliable network connection even more frustrating. In previous years, she had become accustomed to using the whiteboards when technology failed. Without whiteboards, Jennifer felt she was left without a backup plan.

After traditional whiteboards were mounted on either side of the television, Jennifer hung large posters of calculators between each of the whiteboard and the television. Class objectives and due dates were written by hand on one whiteboard, leaving the other for workspace as needed. On the outsides of the whiteboards, student projects from Jennifer's previous classes were hung. The left wall of the room was filled with graduation photographs and other photographs of previous students as well as student art work given to Jennifer, newspaper clippings about the school, and a class bell schedule. A single poster displaying the digits of pi on this wall was the only décor, aside from the graphing calculator posters, that related specifically to mathematics. At the back of the room, the standard-issue wastebasket was covered in brightly colored happy face fabric to make even the wastebasket "happy and pretty".

At the beginning of the spring semester, Jennifer's room was filled with the standard student desks to which the chairs were permanently affixed. However, in February, these desks, along with Jennifer's desk, were replaced with new furniture purchased as part of the construction and renovation bond. The new student desks were trapezoidal and meant to be able to be used in multiple configurations, so that teachers could easily have students work in pairs or in groups of up to six students. After these desks were delivered, Jennifer routinely changed the configuration of the desks in her room, attempting to determine which configurations worked best for both lectures and group work.

The day that the new desks were delivered, Jennifer's classes were temporarily moved to another classroom. It was the second of three Wednesdays in a row in which the normal routine in Jennifer's classes was disrupted. The previous week, she had been called out of class to attend an interview for the district-wide teacher of the year award. In the week that followed, she was pulled from class to help facilitate and speak at an orientation session for 8th graders who would be attending the high school the following year. Later in the semester, she was again pulled from class to proctor standardized exams. Jennifer had mixed feelings about these interruptions. Because she had both a co-teacher for two of her sections and, during the spring semester, also had a student teacher intern who, by mid semester, Jennifer trusted to run classes without her, she felt she was more able to tolerate such interruptions than any of the other teachers in her department. However, she acknowledged the challenges such interruptions created: "It's hard to know where to start or where to go when I don't know what happened yesterday." This quote illustrates that Jennifer relied on her ability to make meaning while enacting curriculum, rather than making meaning from her written curriculum materials. When the other participating teachers were absent, they would generally return and implement lessons (either the one that was meant to be taught the day they were absent, or the next lesson in the sequence) with few if any changes, but Jennifer felt it necessary to develop an understanding of what had gone on in the classroom in her absence. Thus, Jennifer would spend a significant portion of the next day questioning students about what they had done and learned without her. In this way, absences were more disruptive for Jennifer than for the other participating teachers. Further, because of her position as department chair and the perception of her as a

leader in the school, Jennifer was given responsibilities that took her out of her classroom more than the other participating teachers.

In addition, Jennifer did not have a planning period. She explained that every year, there seemed to always be one additional math section needed than could be covered by the department. As department chair, Jennifer decided to take on the additional course as an extra duty assignment herself, rather than burdening another teacher. Thus, her planning period was replaced by the additional teaching assignment. Therefore, Jennifer was only able to work with curriculum materials before and after school. When she did, most of the time her goal was not to make meaning with them, but rather "refresh" herself on the lesson from the previous year.

While Jennifer typically used the same materials for each Algebra 2 class on a given day, her enacted lessons were often wildly different. Jennifer attributed this to the differences among her classes. Not only did she co-teach two inclusion classes with Sarah, but she also had one section of Algebra two that primarily consisted of advanced 9th grade students. Jennifer had very different goals for each of these classes:

> I have a lot of IEP kids and you know, seniors that are, that's their final math class; they're not super strong in math. So, we put those with the team-taught classes. So, it's a challenge to try to get them to appreciate the math, that's my goal for them. For my ninth graders, you know, my goal for them is to push the bar a little bit. I've got to teach them all the regular standards and stuff but push the bar and kind of try to, ask them well, like, why? Well, how is this going to work? Try to get them to discover things.

Because of these different goals, Jennifer approached the classes very differently. For example, in her team-taught classes, Jennifer often began lessons by inserting blank pages at the beginning of the lesson's notes and asking students what

they remembered about a prerequisite topic, taking notes down as students volunteered information and them filling in the gaps of their knowledge before beginning to address the lesson as written. This often meant that the co-taught classes did not reach the more nuanced or advanced discussions in the lesson, but Jennifer saw this as a feature rather than a bug. To her, this allowed each class to get what it needed from the lessons.

Jennifer also tended to add blank pages to the lesson for her class of 9th graders as well, but these came towards the middle or end of the lesson, as students began to ask about alternative methods of approaching the problems. Oftentimes, Jennifer would remark that she was not "seeing" what the student was seeing and ask the student to write their method on the reserved whiteboard or tell her what to write on her mobile device. After the alternate solution was recorded, Jennifer would ask for input from the rest of the class "Ok, what do you guys think? Can we do this?" In interviews, Jennifer said she used this time to try to determine if the method was valid or not, but that if neither she nor any of the students could think of a reason it was not valid, she would assume it was correct. Only once during observations did Jennifer assume a solution was correct when it was not. In that case, another student, who attempted to use the method on a different problem while the class was working independently, realized why the method would not always work. After having the student explain it to her, Jennifer simply stopped the class and had the student share their observations, thereby correcting the mistake.

Because of her desire to be able to respond to her students, Jennifer did not routinely make meanings from written materials, or even create written materials for her lessons. She says:

> You can't force everything, whatever is naturally going to come about in the classroom. So, if I were to make lesson plans and truly write it out, it would probably look kind of puny. Because you have to wait until those thirty kids are in here and you see what they are going to say.

As such, Jennifer rarely made new meanings from curriculum materials before enacting them. When she did, it was almost always during collaborative planning meetings. Usually, the new meanings she made were based on the input and ideas of the other team members rather than the written curriculum materials themselves. While she strove to understand the new meaning being made in the collaborative sessions, she did not always adopt them herself. Often, she would endorse them by saying "that could work" or "It's worth a shot", but this did not necessarily mean she planned to implement the new meanings. In fact, although the other team members looked for her endorsement when presenting new ideas, Jennifer, in interviews, repeatedly shared her belief that "you never know until you try", but generally left it to the other teachers to try. The few times she did implement new ideas, the teachers who had presented them had already tried the idea in their classes and experienced success with them. However, as planning sessions were generally forward-looking, the teachers rarely used the time to reflect on the new ideas that had been proven successful in the previous units. Thus, Jennifer made few changes to her curriculum for much of the semester. In fact, Jennifer kept a flash drive with previous versions of several lessons stored on it. She explained that the team had changed the lessons to something she did not believe would work as well, and thus kept the previous version intact for herself. For the most part, many of these changes were in form rather than substance. Jennifer explained that, as they continued to refine their lessons, most of the teachers tended to add more information

and structure to the slides which would be projected during the lessons. Because Jennifer improvised so much during her lessons, she found the slides with less information and structure more useful, preferring to add the information, using her students' words, herself.

Ironically, as the participating teachers began to plan for the guided inquiry unit, Jennifer, who was used to routinely changing lessons at a moment's notice to respond to students, was more hesitant to implement the guided inquiry unit than the other participating teachers. In collaborative planning sessions, she stated she was nervous about the lack of control she would have during the unit: "You don't know what they'll come up with and you'll just have to go with it". However, when questioned further, her fears were more nuanced. Because the new unit of curriculum was created to implement a guided inquiry framework, Jennifer felt the need to closely adhere to the framework, which she felt would limit her ability to respond to students and make meaning with them; instead she felt that the unit structure required students to make meaning on their own. "For guided inquiry, you just have to let them go and see what they come up with and accept it."

Because of her fears, in the collaborative planning sessions, Jennifer advocated for infusing the materials created for the guided inquiry unit with the previously used materials for the unit, with which she was more comfortable improvising. While this was initially met with resistance from some of the other teachers, especially Sarah and Emily, in the end the unit that the teachers implemented infused the previously developed lessons for the unit into the guided inquiry framework.

Sarah: Making Meaning of the Professional Community

Twice a day, Sarah crossed the length of the school to co-teach with Jennifer in her classroom. However, when not in Jennifer's classroom, Sarah's classroom was a respite for herself as well as her students. Often, Sarah kept the lights low in her room, relying on the natural light that entered the row of windows at the top of far wall near the ceiling. Beneath these windows, a windowless door opened to the outside, and students often opened the door and stood in the doorframe between classes or during a break from their work. Next to the door, low bookcases were topped with logic-based board games. Soft music could sometimes be heard when entering the class. Some motivational posters in neutral colors hung neatly on the walls, and student-created posters illustrating different strategies for solving equations were displayed above the bookcases. Unlike the mathematics educators' rooms, Sarah's room contained round tables that could seat four to six students and thus students entered expecting to work in groups.

Sarah's classroom was situated very near Emily and Jessica and was adjacent to Amanda's room, but felt separated. This was in part due to the very different environment Sarah created in her room; while the math educators described their rooms as engaging and energizing, Sarah wanted her room to be comforting and relaxing. Large structural support columns located between Sarah's room and Amanda's room made it impossible for the two teachers to see each other when standing near the doors of their room and added to the feeling of separation. While Emily, Amanda and Jessica often reflected on or planned for classes during class exchanges, Sarah rarely joined in these discussions. In part, it was difficult to join the discussion because during four of

the seven class exchanges, she was travelling to or from Jennifer's room. However, because these conversations were held beyond the structural support columns that separated Sarah's room from the other teachers, it was also impossible for Sarah to supervise students within her room while participating in these conversations. When she did join in the conversations, it was often solely as a listener. Because she co-taught with Jennifer, who was not able to collaborate with the other teachers frequently, Jennifer's lessons often differed significantly from the lessons of the rest of the team, despite using the same written curriculum materials. Thus, Sarah found that she did not relate to what was happening in the rest of the team's classrooms. At the same time, because of the location of her classroom, she was not often able to debrief or plan with Jennifer either.

When co-teaching with Jennifer, Sarah initially assumed a decidedly secondary role. Jennifer led most of the lessons, with Sarah working with small groups as needed. Although they had already been working together for almost five months, at the beginning of the spring semester, both Jennifer and Sarah remarked that they both still needed to learn about each other to better work together. As the semester progressed, Sarah began to take a more active role in class, interjecting comments and suggestions or asking clarifying questions when she felt some of the students were confused. In interviews, Sarah described how it took time for her to adjust to Jennifer's teaching style. Previously she had worked with a teacher who was very scripted in her lessons; Sarah found it harder to interject herself into lessons when she was not confident of the direction Jennifer was headed. By the end of the year, however, Sarah came to appreciate Jennifer's teaching and was confident in their ability to co-teach.

In other ways, Jennifer's teaching still presented problems for Sarah. Sarah's Algebra 2 applications classes were meant to support students with special needs in Jennifer's co-taught Algebra 2 classes. Because she was unable to predict what a lesson in Jennifer's class might bring, she was unable to prepare her students for lesson in advance, as she had been used to doing. Instead, she began to reinforce concepts after they were presented in Jennifer's class. While she uses additional curriculum materials from the collaborative curriculum library that all the teachers utilized, she felt her approach to choosing material was different than the mathematics educators' because of both her position as a special educator and her own experiences as a student who struggled in mathematics classes.

> I always had a hard time in math. I wasn't very good at it in high school and in middle school and so, I kind of understand the challenges. People that have problems learning math. Because some people just don't have the math brain yet, they grow into it. And teaching math made me kind of look at it a different way and I'm able to maybe explain things in a different way to get kids to understand, if that makes sense. How I would try and learn is how I would relate it to them. I'm good at math now, but back then definitely not at all.

When asked what kinds of activities she felt helped struggling students make sense of mathematics, she replied:

> I like to do a lot of interaction with them and ask them questions and answers and have them group together and like, if we are trying to solve a problem, 'well, what do you think? How would you do it?' If they say like I don't know, obviously, I'm going to be like, well let's look at it this way, let's look at it that way, kind of self-discovery in a sense. Give them a little more ownership over what they do. And I like them to work in groups because they can talk to each other and have ideas with each other and they can show each other how to do things. Because, you know, and I've told them this before; the reason I know how to do math is because I've taught it. And that's one way of learning. If you teach someone else, you are better at it… And that, just, is something that I've learned and it's been in research and it's something that I know of that's

> important. That teaching, that teaching thing with peers. It's very important.

Thus, along with her own experiences as a struggling mathematics student, Sarah also relied on pedagogical knowledge and research to decide what curriculum materials to use and how to use them. In observations, she stressed both peer teaching and the need for her students to take ownership of their learning. As students worked in groups, she often reminded students to ask each other questions before asking her. In addition, she would often counter student questions by asking her students purposeful questions in return like "how could you find that out?", "How did you get to this point?", and "What could you do differently?".

Despite Sarah's strong convictions about how to best teach mathematics to her students, in collaborative planning sessions, Sarah was almost entirely silent. She only began to speak during these sessions as the team began to prepare for the newly developed guided inquiry unit. During these sessions, she voiced her beliefs that the guided inquiry unit would help students take ownership of their own learning and was excited to implement the unit. However, as the mathematics educators, particularly Jennifer, began to discuss changing the unit to include the previously designed lessons as well, Sarah quickly fell silent, deferring to the mathematics educators. Still, for her students, the infusion of these old lessons was restricted to the co-taught sections of Algebra 2. In her Algebra 2 Applications classes, she adhered to the guided inquiry framework, using class time to engage students in conducting further research or making new meaning from the research they had already gathered.

Emily: Making Meaning of the Practice of Teaching

Emily's classroom was constantly changing throughout the semester. When I first entered the space in January 2017, several ceiling tiles were missing and cables hung from the spaces left by the missing tiles. Other ceiling tiles had evident water damage. Emily explained that the construction of the new wing, which would be adjacent to her room, had caused the water damage on three separate occasions. In addition to the damage ceiling tiles, student work had been destroyed, her carpeting began to recede from the walls, and student was sprayed with falling water. Emily's planning period was periodically interrupted by construction personnel assessing or addressing damage, or running cable though her ceiling. In addition, technology staff were frequent visitors to her room. Possibly also due to construction, the interactive white board in her classroom presented technological issues throughout the semester; sometimes the markers suddenly became misaligned, at other times the screen flickered, suddenly turned off, or appeared green, red, or yellow.

Despite these difficulties, Emily attempted to make her classroom a positive environment for her students. Black framed motivational quotes printed in black and turquoise fonts were hung along the bright turquoise wall lined with cabinets at the back of the room. Organizational in and out bins for each class, a tin pail full of pencils, and workbooks used in some of her classes were arranged neatly on top of the cabinets. Because the pencil sharpener had been ripped from the wall as part of the construction, an electric pencil sharpener sat next to the pail of pencils. The cabinets were already starting to fill with additional manipulatives and supplies Emily had inherited from previous teachers assigned to the room or had purchased herself. Student desks were

rearranged regularly; sometimes they all faced the interactive white board directly, at other times, each side of the room faced the other, or were arranged in small groups. Emily's desk was on the opposite side of the classroom, to the right of the interactive whiteboard. On the opposite side of the interactive white board, examples of "productive thinking" were posted. For example, one line instructed readers to think "I haven't figured out how to do this yet" instead of "I can't do this". The side walls had large white boards mounted on them. Along the right wall, under a high set of windows that were now obscured by the construction of the new wing, the white boards were used to post the schedule for the week for each class as well as a bell schedule for the school. The opposite wall, after the first flooding incident, was used to post student work.

Finally, above the door hung the saying that most applied to Emily herself; "You miss 100% of the shots you don't take." Emily was the girls' junior varsity basketball coach and the assistant varsity coach. She hung this saying because it used a basketball reference to encapsulate what Emily believed a positive disposition meant, and thus she felt it was very appropriate for her room. This saying, however, also encapsulated Emily's approach to the year; she rarely failed to take a shot at something new. Through the course of the semester, she changed classroom rules, her organizational structure, desk arrangements, seating charts, procedure and plans. Because she was a first-year teacher, she had not yet determined "what works" for her and did not hesitate to try something new when she believed the current system was not working.

Early in the year, in addition to the construction damage to her room, Emily said she also had difficulty due to construction noise.

> They had been working on the roof and … it was so loud that we couldn't even hear. I mean this kid right here (pointed to front row) was like 'I couldn't even hear you.' And that was when I'm like, trying to yell. And so, we'd have to pause. And I'd pause, and as soon as it died down, I'd speak really fast like ok guys let me get this in, and then I'd talk… it was bad. It was so bad.

These disruptions and disturbances made it difficult for Emily to make sense of her classroom; she needed to try many different systems of classroom management and organization before she found one that seemed to work for her.

Just as physical elements in her classroom sometimes failed and were replaced, managerial elements sometimes failed, requiring updates or replacements. For example, in interviews, Emily described how she was hesitant to confront behavioral problems in her classroom in front of other students, opting instead to talk to the misbehaving student after class or out in the hallway during times of independent of group work. However, she came to believe that doing so did not effectively address the behavior. She then decided she needed to address misbehavior immediately, and was careful to discuss misbehavior as disrespectful not to her, but to the other class members. She found this to be a more effective procedure, and by Christmas felt that misbehavior was easy to address and that the key is to address issues swiftly but not to bring more attention to it than necessary; "nail it, knock it out, and then that's it. We're good." For Emily, misbehavior is akin to making a mathematical mistake; neither are desirable, but she feels strongly that her students need to know it is okay to make mistakes, if they learn from their mistakes and keep trying. Indeed, she stresses the importance of perseverance and sees perseverance as a key aspect of her teaching. She constantly talks to students about mathematics in terms of learning how to think and believe reframing

mathematics in that way prevents some of the behavioral problems she saw at the beginning of the year. For example, she discussed how students would interrupt lessons to ask the stereotypical "when are we ever going to need this?" question at the beginning of the year, but slowly stopped asking that question as she began to talk with them about mathematics as a process of learning how to learn. "I never get that question anymore, which makes me happy. Because they're like, ok, we're doing this because I'm learning how to think, and that's a process." While Emily has long believed that learning how to think is a fundamental purpose of learning mathematics, she learned the importance of sharing this belief, and of setting goals in general, over the course of the year.

With so much focus on classroom management and construction related issues, Emily had little time to make meaning about from her curriculum. Instead, she relied on her fellow teachers to supply meaning for her. She relied heavily on Jessica, who had been assigned as her mentor teacher. The other participating teachers largely decided what curriculum materials to use on what days without her. In addition, they gave Emily advice on what to emphasize or gloss over in each lesson, what students might find difficult about each lesson, and even how to group students or organize materials for specific lessons. For much of the year, Emily was grateful for the support offered by the team and questioned whether she would be able to properly prepare for classes without their support, much of which was given in small increments between classes

> I'm like, I have no idea how to go about this, do you have a good idea? So, a lot of times, it's in the hallway during passing periods, because we have ten-minute passing periods, so they'll just sort of throw some stuff out at me, and then have class, and then go back out and like, ok, yeah, back to this conversation. And then, sometimes we like, we'll sometimes meet together as a big group and plan some stuff.

Even with this support, Emily struggled to find enough time for planning. In the fall, she often was at school two hours early for freshman practice and stayed after two to three hours for varsity practice or games. In addition, Emily often came into the school on Sundays for two or three hours to prepare for the week ahead. During this time, she would grade student work, organize materials, including the student desks, for the week, and write the weekly schedule for each of her classes on the white board in her room. In other words, much of this time was spent preparing the classroom for the week. Sometimes, if time allowed, she would also work some or all the problems which were to be used in her classes for the week. She only did this if she had time after she felt her classroom and materials were sufficiently organized for the week. Emily realized early in the year she would not be able to continue the schedule she had created for herself early in the year.

> In the beginning, I was killing myself. I got to Fall break and I was like 'Thank God, because I am going to die.' And so, from that point I was like, yeah, I've got to change, because this isn't working. I am not going to make it. So, I'm just trying to kind of let things go. This is what I was worried about in the beginning when I started. Because I'm a perfectionist, big time, and in the beginning, I was like, this lesson didn't go how it was supposed to and it irritated me. So now, I'm kind of like, if it didn't go well, they still probably got the material, they probably didn't realize if it wasn't as good as I wanted it to be. I'll just make it better next time.

By spring, basketball season had ended, alleviating her time constraints. As the semester progressed, Emily began to think more about what materials she wanted to use, rather than relying solely on the input of the other teachers. As she slowly found more time to plan, she began to infuse the curriculum materials with her own ideas.

> I'll tweak it for myself. I'll pull up their notes and think about, yeah, I can do this with it. Sometimes, if I'm not finding like exactly what I want but I kind of know what I'm thinking in my head, I'll just like google kind of what I'm thinking and something pops out.

In addition, as the spring semester progressed, Emily began to reflect on the lesson she gave in class and think about how they could be improved. "I'm always thinking, I'm writing notes, this is what I want to do next year." In other words, Emily did not just attempt to make meaning from her lessons for the current year, but also attempted to refine her understandings of the lesson to make better meanings from them for future years.

Yet, during collaborative planning sessions, Emily rarely spoke, except to occasionally ask a clarifying question. It was not until late March, when the team began considering how to implement a new guided inquiry unit on sequences and series that Emily had helped to create with Jessica and Jennifer the previous summer, that she began to offer her own thoughts on the curriculum materials. Her willingness to give input into this unit surprised both Jennifer and Jessica, who viewed the guided inquiry unit as something very different than the other units in their curriculum, and assumed that Emily would prefer to present the material in the traditional way. But for Emily, both the traditional unit and the guided inquiry unit would be new experiences. She saw the guided inquiry unit as just another opportunity to experiment and try something new, as she had been doing all year. Thus, during the first collaborative session in which they discussed the unit, Emily was quite vocal and encouraged all the team members to embrace the new structures of the guided inquiry unit.

Unfortunately, the second collaborative planning session for the unit occurred at a time of great stress for Emily. She had recently been notified that if she wished to continue coaching basketball, she was required to obtain a commercial driver's license so that she could drive the team bus if a bus driver was unavailable. Thus, her time and energies were spent making meaning of the study material for the license rather than curriculum materials for her class. In addition, the second collaborative planning meaning about the guided inquiry unit took place directly after a parent teacher conference that had a significant negative impact on Emily's confidence. During the conference, the parents implied that their student was not being successful because of Emily. By the time Emily arrived at the collaborative planning meeting, she was convinced she was an ineffective teacher and was near tears. The beginning of the meeting was then devoted to discussing the situation. Both Jennifer and Jessica pointed out that the student had not taken advantage of some opportunities Emily had provided. While this seemed to ease Emily's mind, she remained quiet the rest of the collaborative session, questioning her ability to implement the unit and deferring to the judgements of the other teachers. Since she and Sarah had been the strong voices for adhering to the structure of guided inquiry, during this second session, with Emily's silence, more changes were made that infused traditional notes into the guided inquiry unit.

Amanda: Making Meaning of Theory and Practice

Walking into Amanda's room felt much like walking into a large dorm room. Along with the somewhat standard educational, motivational, and mathematics posters, posters displaying characters from movies, video games, and comic books papered the otherwise plain white walls from floor to ceiling. At the far side of the room, a painted

mascot covered the run of windows at the ceiling. Beneath them, a white board displayed the daily objectives for each class. Curtains adorned the windows that stretched to the floor on either side of the room and a floor lamp and table lamp that might otherwise be found in any home in town completed the cozy feel of the room. A table top Christmas tree, whose ornaments changed to hearts in February, shamrocks in March, and flowers in April, sat atop a bookcase behind Amanda's desk, which was situated next to the interactive white board on the right-side wall and generally had garland in the same theme as the Christmas tree draped across the front. Most days, the desks on either side of the interactive white board were placed in rows facing each other, except for some two-person tables to the right of the interactive white board that Amanda acquired because she noticed how some of her taller and larger students could not sit comfortably in the seats which were fixed to the typical student desks. Behind these desks, caddies for graphing and scientific calculators lined the top of cabinets.

At the beginning of spring 2017, Amanda was confident in her teaching ability. In interviews, she discussed how she had grown in her first three years of teaching and had finally reached a point where she felt familiar and confident in her ability to create effective and coherent plans for her classes. She attributed much of this growth to Jessica's unofficial mentorship, referring to Jessica as her "rock". Because Jessica and Amanda had the same planning period, they routinely planned for Algebra 2 together. Amanda reports that Jessica helps her to decide how to alter the written lesson plans from their collaborative curriculum library to better meet the needs of her students. When they planned together, Amanda would often read through upcoming lesson plans while Jessica made keys for assignments or assessments. When Amanda struggled to

make meaning from the lesson plan, she would turn to Jessica for assistance. Often her questions were phrased as alternatives, asking Jessica to choose the better option. Many times, she differentiated her response based on their classes, often choosing one alternative for her class of mostly 9th graders and another for Amanda's class of mostly 12th graders. Because they focused on meeting the needs of their different classes, both Jessica and Amanda have developed a sense of not only their own students, but also of the other's students. During initial interviews, Amanda was emphatic that planning effectively depends on

> …knowing your students. Knowing what my sixth hour, of the older students, is going to look very different from an activity that perhaps her [Jessica's] young 6th hour is going to do. Where we may look at, for example, a synthetic division problem that has every single coefficient in the problem, maybe [Jessica's] is going to start with something missing the x-square term. I mean things like that, how you are kind of scaffolding, she can let her younger sixth hour maybe figure it out, where I can ask my kids 'ok, so what do we notice?'

Amanda soon began to question this stance. During the Spring 2017 semester, she was enrolled in a graduate level mathematics education course that focused on problem centered learning. This course shook Amanda's confidence in a profound way. She questioned the pedagogy she had been using, saying "I need rules and order, that's how I work, but is that how my kids work? Is that what they need? I am giving them what they really need?"

In response to her self-doubt, Amanda attempted to implement a fully problem centered lesson. While this lesson was not observed, by Amanda's account, it was a "disaster. They didn't know what I wanted. They wouldn't stay on topic, it was just chaos." The experience was devastating for Amanda: "I went home and cried and said I can't do this. I'm not a good teacher. I need to start thinking about another job. These

kids deserve better." However, she was slowly able to regroup and regain confidence. The next day, she returned to a very comfortable lesson format for her consisting of notes and small group problem solving. Over the next week, she also sought advice from both her professor and her colleagues. Based on their advice, Amanda decided to try and take smaller steps. Two weeks after her 'disastrous' lesson, she introduced a non-routine problem as bell work for her classes as they began a unit on exponential functions. The question directed students to find three positive integers, a, b, and c, such that their sum was nine and the value of $a(b)^c$ was as large as possible. Each of Amanda's classes was observed as they tackled this question. In the first class of the day, Amanda was visibly nervous, interjecting herself into the conversations of the groups of students in her class as they discussed the problem and guiding them towards methods that would facilitate their problem solving. However, as each class had a positive reaction to the problem, commenting that it was interesting or expressing surprise at just how large the value of the expression was for certain values, Amanda began to create new meanings for the activity. While her first class worked on the problem for less than five minutes, but the end of the day, Amanda gave her last class fifteen minutes to discuss the question, and engaged the students in discussion about how they could determine they had found the largest possible value, instead of simply asking what the largest value they found was. In other words, Amanda created more meaning from this activity as she implemented it throughout the day.

Just as Amanda's confidence was returning, an announcement once again shook her confidence and changed the way she approached making meaning of her curriculum. Because of the renovations to the building, the teachers had known that

many teachers would be assigned to new classrooms the following year. While many of their fellow teachers expressed strong desires to be placed in the newly constructed wing, Amanda strongly expressed her desire to remain in her current room to administrators as well as Jennifer, her department chair. “I’ve put a lot of work into my room making it my own, making it a happy and cozy place for my students. It took a lot of work, and I don’t want to have to do it all again.” Despite these views, it was announced that the math department would be placed so that half of the department had classrooms in the newly constructed wing, while the other half were placed in the old wing south of their current classrooms, one of the few hallways in the building that would remain unrenovated. Amanda has been assigned a classroom that was not only significantly smaller than her current room, but that was also rumored to contain mold. Amanda believed that both the current teacher in the room and the teacher who had previous taught in it had become sick after being assigned the room.

The news of her reassignment was very emotional for Amanda. She again reported crying for hours at home after hearing the news. She also spent her planning periods during the next week attempting to address her concerns with the room. She spoke with the teacher currently assigned to it and reported that the teacher confirmed that she had begun to get sick after being assigned the room. This greatly concerned Amanda, who suffered from severe allergies and had been asthmatic as a child. She then spoke to her union representative, who accompanied her to speak to administrators, who gave her assurances that the room would be inspected and any mold would be abated and agreed to deep clean the carpeting in the room. However, Amanda reported that during this meeting, the administrator implied that part of the reason she was assigned

to an unrenovated room was that the administrators realized she would 'take care of' the room. For Amanda, this felt like she was "being punished for caring" and putting effort into creating a positive classroom environment. Still, the administrator's assurances that the room would present no health problems for her eased Amanda's mind.

While Amanda's heath fears were calmed, she was still concerned about the size of the room. "My thirty-two kids barely fit in this [current] room, and that [assigned] room is two thirds the size. How are they even going to all sit, much less walk around or work in groups during activities?" Questions like these seemed to be at the back of Amanda's mind for the rest of the year. After room assignments were announced, when planning with Jessica or as a collaborative group, she often would often ask how interactive activities would "work" the next year, given her limited space. Clearly, Amanda was planning not just for the current year, but also for future years.

When Jennifer suggested that she could take her classes to one of the common spaces that were being constructed as part of the renovations, she nodded thoughtfully but then added "the problem is you never know who else will want to be in those spaces, or if the football team or band will come barging through in the middle of the period." Still, this suggestion seemed to ease some of Amanda's fears and she began to comment that she would "have to" take her classes to a common space next year when discussing certain activities that required space to move. By the end of the year, she had embraced, or at least accepted, the change in rooms and had made plans to return over the summer to construct bookcases and paint the room.

Jessica: Connecting Meanings Made

It was difficult to know where to look first in Jessica's room. She had painted various walls in her room turquoise, coral, and lavender. Over thirty posters addressing a variety of topics from careers in mathematics to a class birthday list papered the walls. Depending on the day, student desks were either in rows facing a central aisle, or in small groups. Jessica desk was positioned at the back of the room, away from the interactive white board at the front. Class schedules were written by hand on whiteboard that also lined the back wall along with bookcases and filing cabinets Jessica had been given and bought over the years because there was insufficient space in the cabinets which lined one side of her classroom for all the manipulatives and materials she had gathered over the years. Jessica had received some of these materials through her participation in various professional development opportunities offered by both the state and an educational outreach center hosted by the local university. Many materials which filled Jessica cabinets, however, had been created or purchased by Jessica. Whenever she successfully implemented a lesson based on materials she had received at a professional development experience, Jessica would alter the materials so that they could be used for other units or concepts as well. For example, during a state facilitated professional development session, she was introduced to a review activity referred to as "cups activities" in which problems of different types were placed in cups around the room and students, working in groups, could choose which problems to solve. While this activity was presented to Jessica as a review of solving equations, Jessica had taken it upon herself to create similar activities for "practically every unit". Eventually, Jessica placed digital copies of these materials in the collaborative curriculum library,

however she retained physical copies, many of which she had laminated so that she could reuse them, in her cabinets.

At the beginning of the spring semester, Jessica was focused on making connections for her students; connection between various activities within a lesson, from one day's lesson to the next, or between mathematics and other content areas or "the real world". For example, when introducing composite functions, Jessica spent a great deal of time reviewing two short activities. The first, which the Algebra 2 team had decided to use in the collaborative planning session, focuses on an analogy between composition of functions and M&Ms (See Appendix C). The activity asked students to determine how they would "build" a peanut M&M. Teachers would then facilitate a conversation which emphasized that to build a peanut M&M, one would start with the *inside,* or the peanut. This process would then be applied to composite function so that the emphasis was placed on beginning with the function inside the parenthesis of the composition. While Jessica liked this analogy, she said that she "had trouble really making the connection between the M&M and the composite function, and I'm really trying to focus on making better connections this year." As such, she decided to include another activity in her lesson (See Appendix C). While this activity was also based on an analogy, that of a family tree, Jessica felt that she could make more connections between it and the idea of a composite function because

> The language is the same. 'The mother of the father of...' is just like 'f of g of…'. And then I can connect and say we could call this the paternal grandmother instead, just like we could call the composite a different name like h.

Because she felt that the family tree activity presented better opportunities to connect the activity to composite functions, Jessica determined that she needed to start her lesson with the family tree activity. Because the rest of the team was using the M&M activity, she also included that activity in her lesson. However, unlike the rest of the team, the M&M activity was not central to her lesson, but rather was presented as an additional perspective on composite functions.

Jessica was also concerned with building professional connections between herself and other mathematics teachers. Officially, she was Emily's mentor teacher, but she also recognized that Amanda looked to her as a mentor as well. "I think [Jennifer] or [another teacher] were her official mentor when she started, but they've always been all the way across the building, and we've always had the same plan, so it just happened." Jessica embraced her role as a mentor in part because she felt she had never really connected to more experienced teachers when she started teaching in the building, and felt like this had kept her from being fully accepted as an experienced department member.

> I know I'm kind of awkward and weird, and I think I was looked at differently because I was alternatively certified, and like everyone else here went to the same university. And the department has always been split between the two sides of the building. So, I just kind of, stuck to myself and did my own thing. But then, after a few years, I tried to reach out, but it was like they still looked at me as the new teacher.

Because Jessica felt she had never been accepted by the more experienced department members, she worked hard to make connections to the newer teachers, both so that she would feel more connected to department member and so that would not have the same experience she did. As such, she made a point of having conversations

with both Amanda and Emily as often as possible, including during class exchanges and at lunch. During these conversations, she often pointed out what part of lessons might need more or less emphasis or what example problems might give students difficulty, or remind Emily or Amanda of upcoming events for which they needed to prepare. Both Emily and Amanda responded positively to these conversations and, as previously discussed, relied on Jessica for guidance in their teaching. These relationships gave Jessica increased confidence in herself. She began to consider returning to graduate school for a doctorate degree and applying for a teaching award.

When she notified Jennifer of her intent, however, Jennifer replied by asking if Jessica knew that there was another teacher in the department applying for the same award. Jessica felt this was a negative response; in an interview, she discussed what she viewed as the 'pecking order' of the department, and her feelings that Jennifer's response implied that it was not her "turn" yet. Jessica responded

> It's like there is [Jennifer] and [the teacher mentioned in Jennifer's reply] and then there are the rest of us. But I've been here nine years. How long do I have to be here before that changes? Before they think that maybe I have something to say, too.

Just after this occurred, the announcement of room assignments again made Jessica question her position in the school; not because of the room she was assigned, but because she was not assigned a room at all. While it was certain that she was moving, the administration was not sure to which room she would be assigned. The administration had been planned for another teacher to head mathematics for the new ninth grade academy, but that teacher had informed the school that they were considering accepting a position at another school. The administration decided that if

that teacher did choose to leave, Jessica would be "the only one they trusted" to head the 9th grade academy mathematics. If she were to be placed in that position, she would be mentoring one or possibly two new hires and teaching Algebra 1 instead of Algebra 2. Initially, Jessica responded with anger: "So I'm good enough that I'm the only one to head math for the academy, but I'm not good enough for an award?" This anger soon gave way to general confusion however. Jessica was unable to make decisions about how to do simple things, like pack her room, because she was not sure which materials she might need in future years. Similarly, Jessica's motivation for making new meanings for her curriculum waned.

> I could make a whole new cups activity or scavenger hunt to review for the chapter, but that's a whole lot of work for one year, and if I teach in the academy, I won't need it. I mean, even trying something new; what if it doesn't work? If I knew I was teaching again and could improve it next year, it still might be worth it to try and see how it goes. But I might not have that option.

As such, not only did she engage in less meaning-making during her planning period, but she also contributed substantially less to discussions during collaborative planning meanings. In addition, when Amanda approached her about the idea of implementing the unit she had created for her graduate class, Jessica, was uncharacteristically dismissive. "The whole guided inquiry unit is going to be new. I don't know if I'm up to trying another whole new unit right away." Effectively, Jessica's meaning-making shut down as she contemplated teaching different courses the following year.

Discussion

The meanings made of curriculum materials by each of the participating teachers were greatly influenced by their physical environments, professional identity and, in the cases of Jennifer and Jessica, how they were perceived (or believed they were perceived) by other professionals in their building. Both Jessica and Jennifer had enough experience as teachers to begin to question and make meaning of their role not only in the classroom, but in the larger school community. While Jessica was explicit in her desire for recognition, Jennifer also took actions to receive recognition, not only by applying for the teacher of the year for the school and district, but by taking on extra responsibilities. These extra responsibilities made it not only hard to find time to make meanings from written curriculum, but also made it challenging to make meaning as curriculum was enacted because of the frequency with which she was pulled from her own classes. Jennifer could create new meanings from the curriculum materials when working collaboratively, but these opportunities were limited because of Jennifer's relatively isolated classroom on the opposite side of the high school; she was not privy to the same discussions and reflections between classes that Emily found so helpful. Thus, left to her own devices, Jennifer mainly relied on curriculum material that had been successful in the past. However, Jennifer engaged in significant meaning-making when enacting the curriculum. Her ability to improvise lessons to meet students' needs and interests made meaning-making from written curriculum materials almost secondary in importance; whatever the intended curriculum was, the enacted curriculum almost always differed significantly because of Jennifer's response to her students. This skill was less developed in the other participating teachers and they, unfortunately, did

not have the benefit of being able to observe Jennifer or reflect on lesson with her on a routine basis because of Jennifer's isolation.

Jennifer also seemed to be much less impacted by the news of room changes than the other participating teachers. Her confidence in her ability to improvise may account for this, or it simply could be that Jennifer did not associate her current classroom with her professional identity as much as the other participating teachers did because she had already been moved more than once in her career, including the previous year. On the other hand, both Jessica and Amanda greatly associated their classrooms with their sense of professional identity and were acutely impacted by the news that they would change classrooms the following year. Amanda saw her classroom as a reflection of her professional identity; for her, changing classrooms was akin to 'starting over'. Jessica, on the other hand, saw the uncertainty in the administration's decision about where to place her as parallel to the awkward position she held in the department; considered a mentor and a leader by some, and 'not ready' by others.

On the other hand, Emily, Amanda, and Sarah had not yet formed well-developed professional identities. As a first-year teacher, Emily was just beginning to develop her sense of professional identity. Amanda was forced to reexamine her identity by her graduate classes, while Sarah found it necessary to reinterpret her identity in the context of a new school, professional team, and co-teacher. Perhaps because their identities were yet well formed, how others perceived them seemed to be of little concern to them unless they were confronted with these perceptions directly, as Amanda was by her graduate classes and Emily was by the parent teacher conference.

Foci of Meaning-Making

There is little research about how teachers use curriculum materials during different phases of their career, or why or how these differences occur (Behm & Lloyd, 2009). The findings above suggest the possibility of three overlapping foci of making meaning for teachers: making meaning about context, making meaning from written materials, and making meaning as curriculum is enacted. Findings indicate that teachers tend to focus on one area of meaning-making at a time. A broad view may indicate that new teachers, or teachers new to a district or school, may begin by making meaning of their context (like Emily and Sarah) and only begin to focus on meaning-making from written curriculum materials after they are confident in their context, like Amanda and Jessica were doing at the beginning of the semester. More experienced teachers, like Jennifer, might focus on meaning-making while enacting curriculum. However, this sequence is certainly not lockstep; changes in context may prompt teachers to return to meaning-making from context to make sense of the changes, as Amanda did when she questioned her role as a teacher. Further, if the future context of a teacher's practice becomes unpredictable, as it did for Jessica, the teachers' ability to make meaning may be diminished. In addition, although teachers may focus on one area of meaning making, they can simultaneous make meaning in multiple ways. For example, although Amanda's focus in response to her graduate class became understanding her role as a teacher, she adopted and made meaning from new curriculum materials to answer this question. Thus, her focus was on making meaning about her context, but making meaning from curriculum materials supported her attempts to do so.

Context

In this case, Emily and Sarah were most focused on meaning-making from their context. While Emily was trying to make meaning of the practice of teaching in a large sense, Sarah was more specifically focused on making meaning of her role within the Algebra 2 team. It may come as little surprise that the teachers new to the profession or the school focus first on meaning-making from their context. This type of meaning-making can only occur once a teacher is placed within a context. Thus, teachers in a new context will not yet have made meaning from it, whereas they may have had experiences with meaning-making from written materials or while enacting curriculum in other contexts, such as another school (in Sarah's case) or from their teacher preparation programs. Yet, context also impacted the meaning-making of Jennifer, Amanda, and Jessica. Jennifer struggled in her meaning-making when her position as a teacher leader within the school pulled her from classes, Amada began to question her role as a teacher after being confronted about her views of her role by her graduate class, and Jessica meaning-making was reduced because of the uncertainty surrounding her future position within the school. Thus, for Jennifer and Amanda, a change in their context prompted new meaning makings, while for Jessica, uncertainty about her future context diminished her ability to make meaning.

This focus of meaning-making from context supports findings from literature about the role of teacher experience. Teachers must understand the skills, experiences and knowledge students already hold (Breyfogle et al., 2010). As teachers gain experience and are better able to anticipate the knowledge and needs of their students, they are more able and likely to focus on big goals for their classrooms and are better

equipped to make adaptations to curriculum materials to meet the needs of their students (Ben-Peretz, 1990). Without such experience, preservice teachers tend to rely more on their teacher education and content knowledge as well as their confidence as a teacher (Behm & Lloyd, 2009). However, the findings of this study extend these understandings by suggesting changes in context, including changes in physical space as well as teacher's confidence in their role of a teacher and place within the school community, may also impinge on teachers' ability to make adaptations to written curriculum materials as they attempt to make meaning from the changes.

In addition, physical placement within the school building, especially in relation to other teachers of the same subject, might serve to increase or decrease teachers' opportunities to engage in meaning making. Emily referred to brief conversations with Amanda and Jessica between classes as significant meaning-making opportunities. Jennifer was unable to participate in these conversations because she was physically isolated on the opposite side of the school. In addition, although there were other influences preventing Sarah from engaging in these conversations, the physical support columns also acted as a barrier because they prevented her from being able to engage in these conversations while still supervising her own room.

Written Curriculum Materials

Making meaning from curriculum materials seemed to challenge both Emily and Sarah, the two teachers new to the school. Emily relied on meanings provided to her by her team members, particularly Jessica. Instead, she focused on making meaning about the practice of teaching. This, too, proved difficult because of frequent changes to the

infrastructure of her classroom. Had it not been for these distractions, perhaps Emily would have begun to make meaning from curriculum materials much sooner in the year.

Sarah had less difficulty making meaning from her new context because she had previous experience and a teacher and thus had made meanings about the practice of teaching. While these meanings, especially the meaning of co-teaching, needed to be modified, they did not need to be fully constructed. In addition, Sarah did not face the constant changes to her physical environment that Emily did. Given that, she could fairly easily begin to make meaning from written materials for her Algebra 2 Applications classes. However, making meaning for her co-taught Algebra 2 classes proved more difficult, and for much of the year she, like Emily, simply accepted the meanings made by the rest of the team. It was not until the last quarter of the year that she began to assert herself during the collaborative planning meetings.

Amanda and Jessica, however, were largely focused on meaning-making from their curriculum materials. This was especially true of Amanda, who spent most of her planning periods with Jessica reading curriculum materials, making meaning from them, and asking Jessica for clarification and guidance when needed. Jessica, on the other hand, focused not on meaning-making from any one curriculum materials, but the larger meanings she could construct by making connections between different curriculum materials. Yet, for both Amanda and Jessica, their meaning-making from curriculum materials was altered or halted when circumstances forced them to reconsider their role as a teacher, in Amanda's case, or their role within the school community, in Jessica's case.

Making Meaning During Enactment

All the teachers made some meaning as they enacted lesson plans. For example, Emily made meanings that prompted her to make changes to her class rules and routines, and Amanda, when implementing the problem centered bell work, made meanings as she enacted it for each class. Jennifer relied more heavily on meaning-making during enactment than any of the other participating teachers. Because of this, and because she was isolated within the building, her lessons often looked very different from the other Algebra 2 teachers. Clearly, Jennifer had already well constructed meaning of her context and her written curriculum materials; this explains much of why her meaning-making occurred during enactment. However, two other factors seemed to have contributed. First, because Jennifer had no planning period, she simply did not have much time to make meaning from written curriculum materials; this may explain her hesitancy to fully embrace the new materials for the guided inquiry unit. Second, her place within the school community seemed firmly rooted; she perceived herself to be, and was perceived by others, as a teacher leader. She was confident in her role both inside and outside of the classroom. Perhaps because of her position, there was never a suggestion that she would be asked to teach different subjects the following year. While she would be changing classrooms, she had changed classrooms more than once earlier in her career. Because of these changes, her identity as a teacher was not intertwined with her classroom space as it was for Jessica and Amanda. Thus, Jennifer was no longer attempting to make meaning from her context in a significant way. Her confidence gave her space to focus on making meaning as she enacted curriculum.

Implications

The findings of the study suggest not only a direct link between a teacher's context and the kind of meaning made, but also a link between context and the quality of meanings made. First, context clearly influenced the participating teachers' confidence, an important part of professional identity which has been shown to influence teachers' meaning making. However, context also influenced teachers' willingness to invest in meaning-making from curriculum materials; in other words, context influenced teachers' motivation to make meaning as well. Finally, context had an impact on the stance with which teachers' approached meaning making.

Context and Meaning-Making

Confidence in teaching is part of a teacher's professional identity. Professional identity includes teachers' beliefs about their efficacy as a teacher, a user of curriculum, and as an authority in the classroom (Remillard, 2005). Remillard (2005) found that teachers' feelings of self-efficacy greatly influence their decisions about how to adapt curriculum materials, especially when teachers are asked to use curriculum materials that promote teaching in unfamiliar ways; essentially, to adapt to new ways of teaching requires teachers to reform their identity as a teacher. Given these findings, it would be expected that Jennifer, of all the participating teachers, would be the most willing and able to use new curriculum materials; but this is not what the findings of this study suggest. Instead, Jennifer had limited time to make meaning from curriculum materials resulted in her hesitancy to embrace new materials. Instead it was Sarah and Emily who were most ready to embrace the new materials of the guided inquiry unit; the two teachers who had not yet made meanings from the previously used curriculum materials

for the unit. Thus, while higher levels of confidence and self-efficacy might increase teachers' ability to make meaning from unfamiliar curriculum materials, these finding suggest that meaning-making ability is tempered by contextual factors such as the physical spaces in which they teacher, their proximity to other teachers of the same subject, and their perceptions of their role within their school communities. These findings serve as further evidence that curricular meaning making is a transactional system which included not only curriculum materials and teachers, but the context in which teachers practice as well.

Further, context may impact teachers' motivation to make meaning from new curriculum materials. Jennifer had greatly invested in the current curriculum materials, since she had used them in years past and had little time to spend making meaning of new materials. In addition, she saw meaning as something created during enactment, not from written materials, and had little motivation to change written materials or the meaning she had made from them. Likewise, when Jessica was informed she may no longer teach Algebra 2, she became unwilling to invest more in making meaning from any Algebra 2 materials, as she believed she would not reap the benefits. Thus, both teachers made a rational choice not to invest their limited time in making meaning from new materials.

Context and Stance

In *The Reader, the Text, and the Poem*, Rosenblatt asserts that the reader must assume what she calls an aesthetic stance while reading for literature to be created. By aesthetic stance, Rosenblatt means that the reader must be focused on making meaning through the experience of reading. She contrasts aesthetic reading with efferent reading,

which she characterizes as reading for utility only; that is, reading to find information that can be utilized after the reading experience (Rosenblatt, 1978, pp. 23–24). Further, she is clear to distinguish that the difference in aesthetic versus efferent reading rests solely with the intent of the reader, and not with the nature of the text; different readers may adopt different stances with the same text (Rosenblatt, 1978, p. 36). Rosenblatt is careful to note that aesthetic and efferent reading are opposite ends of a continuum, and that most readers will use tools and actions characteristic of both types of reading as they read, regardless of their intent or the text with which they are transacting (Rosenblatt, 1978, pp. 27–28). The key is to distinguish towards which end of the spectrum the reader takes his or her stance. That is, we need to come to understand if a reader is reading primarily for efferent or aesthetic reasons.

If we are to apply transactional theory to the meaning-making of teachers, then it is important to understand the aesthetic-efferent continuum in the context of teaching and curriculum. Emily is a clear example of meaning-making form curriculum using an efferent stance. She accepted surface level meanings offered both by the written curriculum materials and by the other team members, and rarely looked for deeper meaning in her curriculum, instead focused on meaning-making from her context. At the other end of the spectrum is Jennifer, who makes meaning almost solely from the experience of enacting curriculum; that is, she is focused on making meaning of the experience of the curriculum. Rosenblatt asserts that the probability that a work of literature is created depends upon how close to the aesthetic end of the continuum a reader chooses to take his or her stance; an efferent stance prevents a work of literature from emerging (Rosenblatt, 1978, p. 35). Extending this metaphor, because Jennifer

made meaning from the experience of enacting curriculum, her curriculum was the most responsive to her students' input and needs, and thus her students were given more opportunities to communicate their thinking and shape the curriculum. This is a key aspect of constructivist teaching, which advocates for much more extensive communication and discourse in mathematics classrooms so that students are able to construct their own methods of solving mathematical problems (Steffe, 1990; Warrington & Kamii, 1998). In constructivist classrooms, learning is viewed as the product of social processes in which new understandings and ideas are formed and shared through social interactions, including discourse (Dieterle, 2010). Thus, teachers must be able to focus on meaning-making as curriculum is enacted, to respond to student discourse during enactment. Therefore, constructivist learning theories suggest that that it would be beneficial for teachers to approach meaning-making using an aesthetic stance that focuses on the experience created during enactment. However, the findings of this study suggest teachers need to have created some meaning from curriculum materials before they are able to effectively focus on making meaning during enactment. In addition, teachers are less like to adopt this aesthetic stance when unfamiliar with their teaching context or when faced with changes to their context. Thus, changes in school policies or adoptions of new initiatives, such as the one-to-one technology initiative in this case, however well-intentioned, may temporarily inhibit the meaning-making of teachers.

Suggestions for Future Research

This study has clear implications for educational policy makers, administrators and teacher educators. The teachers in this study illustrate that meaning-making is a

multi-year, multiphase, recursive process; making meaning of curriculum materials and during enactment relied on teachers' understanding of both their current and future contexts. This process can be, and for several of these teachers, was, disrupted by changes in their context, in terms of new initiatives, like the one-to-one technology initiative, changes in school or classroom environments, or changes in teaching assignments.

Policy makers and administrators should carefully weigh the impact of new initiatives and changes in teaching assignments (both in terms of locations and subjects) on teacher meaning-making when determining if and how to adopt changes. When changes are adopted, policy makers should consider ways in which to support teacher meaning-making of the changes, to minimize the disruption of their long-term meaning making. Further study is needed to determine the best ways in which teachers can be supported during such changes in their context.

Additionally, this study raises a host of questions for teacher educators. How can teacher educators best facilitate the development of pre-service teachers' meaning-making abilities if, as these findings suggest, making meaning from curriculum materials or while enacting curriculum relies on first understanding context? Are there methods that can be used to develop pre-service teachers' ability to make meaning from context even before they are placed in a specific context? Alternatively, what can be done to allow teachers to more effectively make meaning from curriculum materials or while enacting curriculum while they continue to make meaning from context? Finally, how can teacher education and professional development programs move teachers towards approaching curriculum from a more aesthetic, rather than efferent, stance?

Further study is needed on how to support teacher meaning-making in teacher education and professional development programs.

Chapter 5: Understanding the Curriculum Meaning-Making System

This study began as an attempt to understand the meaning-making process used by teachers to transform written curriculum materials into enacted curriculum. While multiple studies have focused on this process (Ben-Peretz, 1990; Clark & Peterson, 1984; Gibson, 1984; Shulman, 1986, 1987; Steffe, 1990; Thompson, 1984), the emergence of standard-base curricula and the proliferation of Internet-based curriculum materials calls into question many of the assumptions made when this work was done. Of particular concern is the assumption that teachers begin with a single source of written curriculum materials (Shulman, 1987). Recent studies have suggested that this is no longer the case (Abramovich, 2013; Larson, 2016; Usiskin, 2010). Thus, I began with the recognition that teachers contend with multiple sources of curriculum materials which they must transform into one coherent curriculum, and I purposefully chose a team of teachers who regularly make meaning from diverse curriculum materials that they have collected into an online curriculum library. In addition, because the participating teachers were not only implementing new state standards for their Algebra 2 classes, but also planned to implement a new guided inquiry unit that some of the participating teachers had designed in the summer before, the case presented unique opportunities to study their meaning making process as moth individuals and as a collaborative professional community.

In each chapter, the meaning-making of this group of teachers was analyzed from different perspectives. Chapter two began with a close analysis of the curriculum materials the teachers have incorporated into their online curriculum library and the processes they use to select from among those materials. Chapter three looked

specifically at the processes used while interacting with curriculum materials. Finally, chapter four examined the specific transactional system in which the participating teachers made meaning and analyzed the way in which their meaning-making was constrained by contextual factors. While each chapter examined the meaning-making processes of the participating teachers from different perspective, the findings presented in each chapter establish that, for the participating teachers, curriculum was the result of a transactional system of meaning-making in which curriculum materials, teachers, students, and context work on and through each other as the meaning of the curriculum emerges.

In chapter two, I focused on understanding how the participating teachers use their written curriculum in their daily practice: how they make changes, what processes they use to make those changes, and how they address issues of coherence and cohesiveness when making changes to their written materials. The participating teachers' practice of gathering the written curriculum materials used in their practice in the online curriculum library they created facilitated the analysis of those materials in comparison to the textbook previously used. I found that the structure of the online curriculum library and the processes used by the teachers allowed for the teachers to collaborate while maintaining autonomy through the use of collaborative planning sessions followed by individual modifications to the intended curriculum. Both during the collaborative planning and individual planning times, time constraint and issues of student engagement and abilities were of primary concern to teachers. Thus, both context (in terms of time constraints) and students played a significant role both in the

development of the intended curriculum and in the decisions about which of the curriculum materials to utilize.

While changes to the curriculum materials were significant, the teachers generally maintained the content and sequencing of the previously used textbook, relying on the structure of the previously used textbook to provide cohesiveness to their curriculum. Thus, while the teachers took ownership of their curriculum on a day-to-day basis, they did not generally address the fundamental questions of what mathematics should be taught or how the concepts taught should be sequenced. When such questions were addressed, it was generally to determine if certain concepts were, in fact, essential to the curriculum. For example, over time, less emphasis was placed on using compositions to explore inverse functions. While, when questioned, teachers explained that this change was to more closely align the curriculum to state standards, an analysis of the standards indicated that this was not the case. Still the change was made. The teachers' belief that the change was made to address the state standards illustrates their hesitance to take ownership of decisions made about what to include and exclude from the curriculum. In other words, the meaning-making of the teachers was largely inhibited by their perceptions of the content and sequencing of the previously-used textbook as well as the state standards; the participating teachers were hesitant to alter these structures. Interestingly, the more experienced teachers were more concerned with maintaining these structures as a means to maintain cohesiveness than the newer teachers. While this might be interpreted as the experienced teachers simply being more comfortable with the current sequencing and structure, it might also be that the more experienced teachers were more acutely aware of the need to maintain coherence and

cohesiveness. Indeed, when the participating teachers did decide to change the sequencing of their curriculum by implementing chapters out of order, the more experienced teachers expressed a desire to return to the order determined by the previously used textbook even after successfully enacting the curriculum with the new order. Given that the teachers did not report noticeable changes in student outcomes, nor any other issues with the enactment of the new order, the desire to return to the old order demonstrates that these teachers gave more authority to the textbook than they did to their fellow teachers when dealing with issues of sequencing. Thus, while teachers maintained a great deal of autonomy over their curriculum, they did not assert full authority over it. Clearly, then, written curriculum materials also played a significant role in the development of the curriculum. Taken together, these findings suggest that students, context, and written curriculum materials all act as part of the transactional system of meaning-meaning of curriculum.

The view of meaning-making of curriculum as a transactional system was further developed in chapter three. While chapter two focused on the meaning-making processes of the participating teachers as a whole, chapter three focused specifically on individual meaning-making when reading written curriculum materials. Findings indicate that the meaning-making processes of the participating teachers are intricate and recursive. Teachers generally read curriculum materials multiple times, attempting to make different meanings with each reading. In general, teachers began by skimming over lessons to ascertain their feasibility in terms of both time and resources. The next concern of teachers was the likelihood that the activities presented in the curriculum materials would engage students in the lesson. As they read curriculum materials for

this purpose, the teachers employed metacognitive strategies that would facilitate meaning-making from a student perspective, including visualization techniques and acting-out techniques. Only if the activities in the curriculum materials were deemed both feasible and engaging did the participating teachers read the materials to assess the mathematical content. During these readings, they would often reread or use self-questioning techniques to make meaning from the curriculum materials.

The primacy of feasibility and student engagement while making meaning from written curriculum materials further adds to the view of meaning-making of curriculum as a transactional system. While it has long been acknowledged that contextual issues and students impact the curriculum as the intended curriculum is enacted (Remillard, 2005), it is clear that students and context also worked through the teachers to influence the intended curriculum as well. It is important to distinguish that it was not simply the teachers' perception of students or context at work, but the realities of available time, resources, and the anticipated presence or absence of students as well as the students stated desires that impacted the intended curriculum. Thus, these factors not only helped to determine which curriculum materials to use (as seen in chapter two) but also how to transform the materials into the intended curriculum.

In chapter four, I endeavored to illustrate the specific ways in which meaning-making is influenced by aspects of the transactional system of curriculum. Multiple studies have been conducted about the role of teachers (Ben-Peretz, 1990; Drake & Sherin, 2009; Remillard, 2000, 2005, 2015; Remillard & Bryans, 2004), students (Remillard & Heck, 2014; Remillard & Taton, 2013; Rezat, 2012; Stein, Grover, & Genningsen, 1996), and curriculum materials (Ben-Peretz, 1990; Stein & Kim, 2009) in

the curriculum process, but few studies have focused on the role of the local context. While chapters two and three highlighted the importance of time and resources in meaning-making, a critical examination of the meaning-making of the participating teachers also revealed that both physical space and professional place also significantly influenced teachers meaning-making processes. The placement of the participating teachers' classrooms in relation to each other, additional responsibilities placed on the teachers because of their roles within the larger school community, and the teachers' perceptions of their identities all worked to constrain and shape their meaning-making processes. Further, unexpected changes in these aspects resulted in interruptions in the teachers' meaning-making processes. For example, the constant changes in Emily's classroom as both the physical structures and technology failed required Emily to constantly reassess and make new meanings from the environment of her classroom. The constant need to improvise meanings limited both the possible meanings she could make, and the time she was able to devote to meaning-making. Sarah was isolated both physically from Jennifer, her co-teacher, and in terms of role, as she was a special educator and taught the Algebra 2 application class that none of the mathematics educators taught. This physical and structural isolation prevented Sarah from fully participating in collaborative meaning-making opportunities. Likewise, Jennifer's relative physical isolation prevented her from engaging in much of the collaborative meaning-making between class periods, which may have facilitated not only her own meaning-making, but that of the less experienced teachers. In addition, Jennifer's role as a teacher leader often pulled her from her own classes, thus constraining her ability to make meaning when enacting curriculum. Meanwhile, the uncertainty around Jessica's

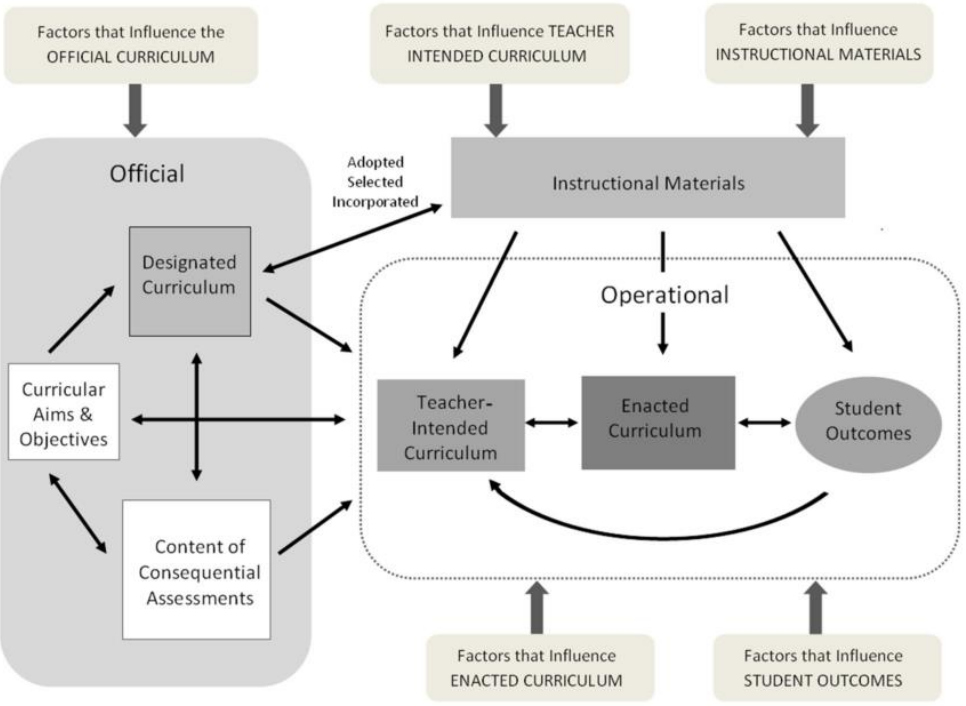
(future) role within the mathematics department negatively impacted her ability and motivation to make meaning. Conversely Amanda's position as a graduate student prompted her to create new meanings about curriculum and her role as a teacher, while news of a change in her classroom diverted her attention from meaning-making about her curriculum. These findings further underscore the role of context in meaning-making both as teachers develop an intended curriculum and as they enact curriculum.

Envisioning the Curriculum Meaning-Making System

Remillard and Heck (2014) envision the processes by which written curriculum materials are transformed into enacted curriculum as the operational aspect of a larger system of curriculum enactment that also involves the official curriculum, as defined by various policies, guidelines and standards, and instructional materials (see Figure 1). Notice that while there are bidirectional arrows indicating that not only do the official curriculum and instructional materials act on each other, but the official curriculum and operational curriculum acts on each other as well. However, this model does not consider the influence of the operational curriculum on instructional models. Traditionally, instructional materials have been created by developers far removed from classroom teachers (Abramovich, 2013). However, the findings of this study clearly demonstrate how the operational curriculum system also influences the curriculum (instructional) materials. Not only did teachers' experiences in the operational curriculum process influence which instructional materials they chose but, as illustrated in chapter two, the instructional materials themselves change significantly as teachers revise and overwrite the previously used materials. While the more experienced teachers still regarded the previously used textbook as the ultimate source of their notes

files, the newer teachers viewed these files as the instructional materials. As they worked to make meaning from content of the files, the content of each changed. Thus, the participating teachers themselves influenced the content of the instructional materials while still continuously adapting these materials as they developed both the intended and the enacted curriculum.

Figure 8. The Curriculum Enactment System of Remillard and Heck



Remillard and Heck also summarize the most often cited influences on each component of the curriculum system: teachers' knowledge, beliefs and practice as well as access to resources are described as influencing both the intended and enacted curriculum. The "expectations" of the local context are also described as influences on the intended curriculum, while "contextual opportunities and constraints" are said to influence the enacted curriculum (Remillard & Heck, 2014). However, the findings of this study suggest that these contextual aspects influence both the intended and enacted

curriculum, just as teachers' knowledge, beliefs, and practices influence both. Because the intended and enacted curricula are also understood to influence each other as well, this calls into question the distinctions between intended and enacted curriculum. To what extent do the intended and enacted curriculum evolve differently? Consider Jennifer as an example of the overlap in these processes; she routinely began lessons with completely blank pages of notes or slides and, because of her limited planning time, only a general idea of the content of the written curriculum materials and focus of the lesson. Her lesson, instead, began by eliciting information from the students directly. As she evaluated the understandings of her students, she was simultaneously enacting the curriculum and developing an intended curriculum for the remainder of the lesson.

Additionally, Jennifer's practice of allowing notes to remain incomplete to allow her classes to construct their own meanings of different concepts presented within the lesson means that the written curriculum is also incomplete as Jennifer begins to enact her curriculum. Thus, the three manifestations of curriculum (written, intended, and enacted) evolve together. While this process is less evident for the other participating teachers in the study, all the participating teachers changed which written materials they would use as well as the content of the written materials based on their intentions for the classrooms. Thus, while we have traditionally considered the enactment of a curriculum as a generally linear process which begins with curriculum materials (including an official curriculum), is transformed by teachers into an intended curriculum, and ends with an enacted curriculum, this may no longer be as accurate a model as it once was.

As teachers begin to weave together curriculum materials from a variety of sources, they necessarily take more ownership in deciding what curriculum materials to use. The process of deciding which materials to use is influenced by the intentions of the teachers as well as previously enacted curriculum. Which written materials are used may depend on the intended curriculum. Thus, we can no longer assume that emerging curriculum begins with written materials. Instead, the written curriculum materials, the intended curriculum, and the enacted curriculum may be different manifestation of the same process of evoking curriculum. Each manifestation gives a unique perspective on the same transactional meaning-making system in which teachers, written materials, students and context work together to evoke a meaning which is both engaging and useful for teachers and students alike.

Although a transactional system of meaning making allows for multiple meanings to be made, we must be aware that aspects of the system can and do work to constrain meaning-making. In chapter four, changes in the participating teachers' context clearly constrained the meanings they could make. The view of curriculum as a transactional system brings to light the importance of each aspect and the necessity of studying both the ways in which each aspect acts on and through the others, but also the meanings that become more or less likely to be made through these interactions.

Further Research

The advent of Internet-based written curriculum materials has fundamentally changed the way that teachers interact with curriculum materials (Abramovich, 2013; Larson, 2009). As such, we have a duty to reexamine the assumptions about the curriculum enactment process that were made at a time when the majority of teachers

had a single source of curriculum. While the findings of this study suggest that the evocation of curriculum is a non-linear transactional system, many additional questions remain. For example, how do local and state contexts influence the curriculum materials provided to and or used by teachers? More fundamentally, to what extent *should* these contexts influence the evocation of curriculum? Further, how do and should students directly influence curriculum materials or the curriculum meaning-making processes?

These questions may have profound impact on the way policies are made and implemented, written curriculum is designed, and future teachers are educated. The role of context, especially in terms of teachers' perceived roles within school communities, is an especially crucial one for policy makers and administrators. Changes in policies that result in changing or unpredictable context may severely hamper teachers' abilities to make meaning of the curriculum. Thus, studies investigating how best to implement change with minimal disruption to the meaning-making process is critical. Additionally, we must question what context not only allow for meaning-making, but facilitates meaning making practices that are focused on research based practices such as providing coherence and cohesiveness, supporting student reasoning and problem solving, and facilitating student communication.

Similarly, conceptualizing the evocation of curriculum as a transactional process calls into question the best practices for designing curriculum. While there has been a movement to create educative curriculum materials that facilitate teacher learning as they are used (e.g. Davis & Krajcik, 2005) little research has been conducted on designing flexible curriculum materials that lend themselves to being integrated with other materials or that allow teachers to make the same type of sustained changes that

allows teachers to return to previously adapted versions of the curriculum materials without creating entirely new written curriculum documents, as the teachers participating in this study have done. Additionally, given the findings of this study, curriculum designers should be cognizant that their materials are less likely to be used if teachers determine that it is infeasible to implement the materials given their local context because of the time or resources involved. Given the variety of contexts in which teachers may work, designing curriculum materials that are easily adapted to a variety of contexts is essential.

Finally, this study raises questions for teacher education. No longer is it sufficient to develop teacher ability to adapt a single state or local dictated curriculum series. Instead, teachers must develop the ability to choose from among a variety of materials, synthesize materials that may originate from a variety of courses, and make changes to the materials as needed to ensure coherence and cohesiveness. As they do so, they must consider and balance the influences of their contexts, students, beliefs, and knowledge. As such, teachers must develop the ability to make multiple meanings from curriculum materials, the strategies needed to evaluate such meanings, and the creativity and understandings to weave different meanings of diverse material into a cohesive whole. To what extent pre-service teachers are engaged in any of these activities during their teacher education program is a question which must be further studied. Ideally, teacher education programs should be designed using the most effective strategies for facilitating teachers meaning-making abilities.

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Appendix A: Semi-Structured Interview Protocols

Interview One Protocol

Knowledge of the Participant

How is the year going?

How are you enjoying your classes / work?

Tell me about your decision to major in secondary mathematics eduction.

Why mathematics rather than a different subject?

Why secondary and not elementary?

Tell me about the mathematics content course you experienced.

What did you learn from them?

What impact will they have on your career?

Tell me about the mathematics pedagogy (EDMA) courses you experienced.

What did you learn from them?

What impact will they have on your career?

Tell me about other education courses you experienced.

What did you learn from them?

What impact will they have on your career?

Participants understanding of Mathematics

How do you define mathematics?

Does mathematics ever change?

Can the meaning of mathematics change over time?

What does it mean to "do" math?

What does it mean to be a mathematician?

What activities are involved in mathematics?

Do you have students who find math challenging?

What makes mathematics challenging/easy?

Did you ever find mathematics challenging?

What is the purpose of learning about mathematics?

What mathematics should all students learn?



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What should students get out of mathematics classes?

Participants understanding of Mathematics Pedagogy

How do you know when a student has learned something in mathematics?

What kind of evidence of students learning is there in mathematics?

Is there a difference between knowing a concept and knowing how to solve a problem related to the concept?

Describe the kind of activities in which student typically engage in mathematics classrooms.

Why should students be engaged in these activities?

What is the purpose of these activities?

What is the role of the teacher in the mathematics classrooms?

How do you know when something has been taught?

What does it mean to teach?

What should the goals be for students in mathematics classrooms?

What skills or knowledge should the student develop?

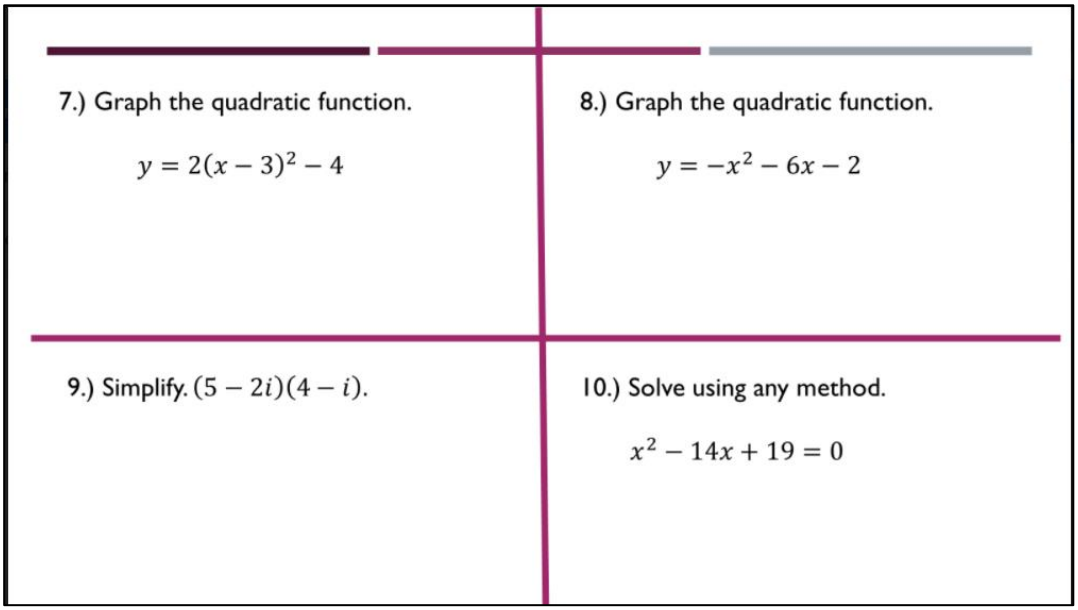
What should they be able to do by the time they graduate high school?



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Appendix B: Artifacts from the Collaborative Google Drive Curriculum Library

Example Goal Quiz



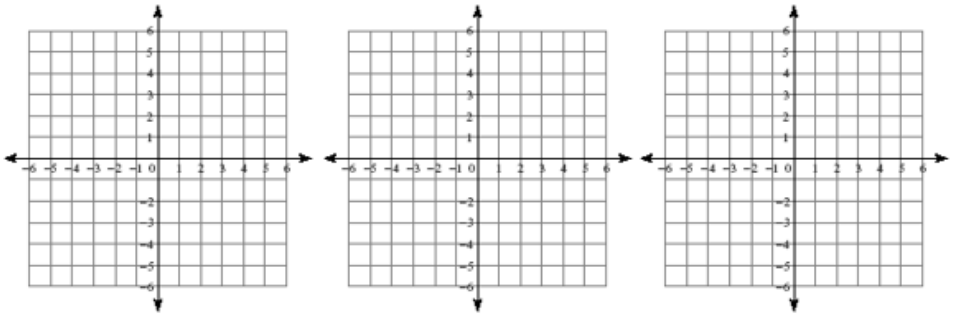
"VertexFormInvestigation"

Algebra 2 Name _____

Vertex Form Investigation Date _____ Hour _____

Use a graphing calculator to sketch a graph of the following quadratic equations.

$y = x^2 + 4$ $y = x^2 - 1$ $y = x^2 + 2.5$

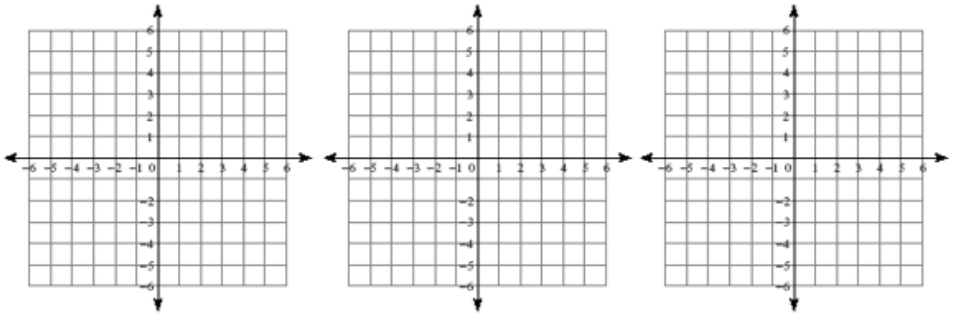


The graph of $y = x^2 + k$ moves the graph k units _____ or _____.

The k is the _____-coordinate of the vertex.

Use a graphing calculator to sketch a graph of the following quadratic equations.

$y = (x - 1)^2$ $y = (x + 3)^2$ $y = (x - 0.5)^2$



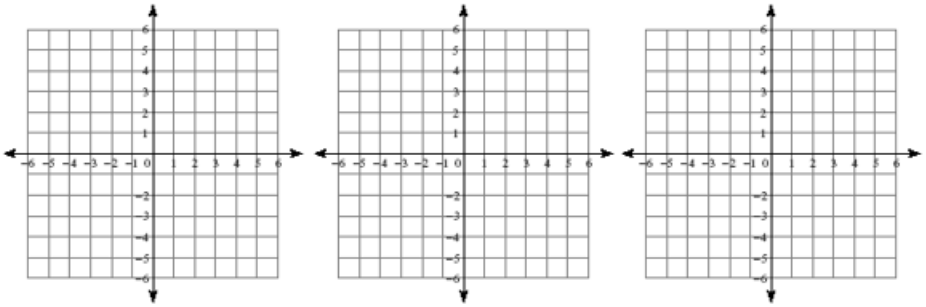
The graph of $y = (x - h)^2$ moves the graph h units _____ or _____.

The h is the _____-coordinate of the vertex.

Combining Horizontal and Vertical Shifts:

Use a graphing calculator to sketch a graph of the following quadratic equations. Then identify the vertex of the graph.

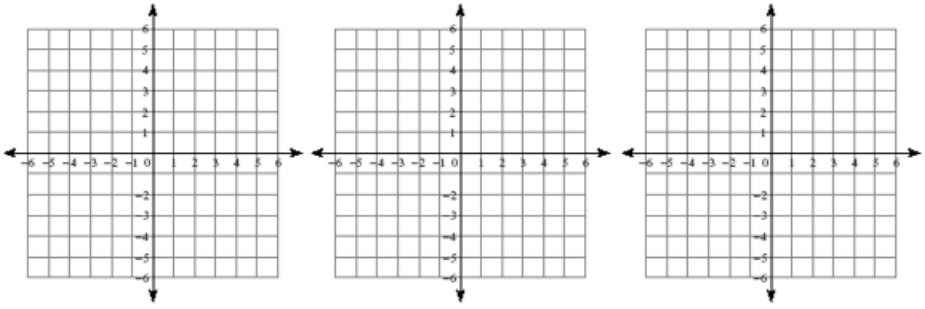
$y = (x + 1)^2 - 3$ $y = (x - 5)^2 + 2$ $y = (x - \frac{7}{4})^2 + 1$



Vertex: _____ Vertex: _____ Vertex: _____

Use a graphing calculator to sketch a graph of the following quadratic equations.

$y = -x^2$ $y = -x^2 + 1$ $y = -(x + 2)^2$



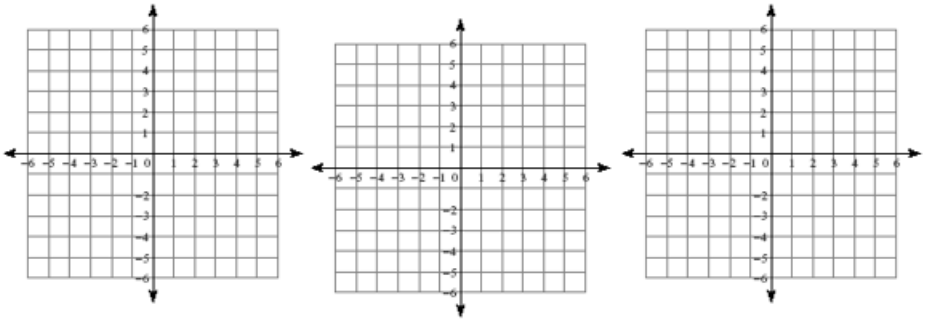
When the leading coefficient is **negative**, then the graph is _____or reflected across the _____.

The graphs are shaped like upside down _____.

The vertex is a _____.

Use a graphing calculator to sketch a graph of the following quadratic equations.

$y = x^2$ $y = 5x^2$ $y = \frac{1}{10}x^2$



The first graph is the parent graph $y = x^2$.
When $a > 1$, the graph got _____ (such as the second graph).
When $0 < a < 1$, the graph got _____ (such as the third graph).

Putting it all together:

$$y = a(x - h)^2 + k$$

(h, k) is the vertex

$a > 0$ opens up (minimum)

$a < 0$ opens down (maximum)

$a > 1$ narrower than $y = x^2$

$0 < a < 1$ wider than $y = x^2$

Solving Using Square Roots

Bellwork: Simplify the square roots.

$\sqrt{25}$ $\sqrt{49}$

$\sqrt{81}$ $\sqrt{100}$

Example 1: Simplify the square roots.

$\sqrt{32}$ $\sqrt{48}$

$\sqrt{27}$ $\sqrt{147}$

Solving Using Square Roots Steps:

1) Get the squared term by itself, if needed.

2) Square root both sides of the equation.

3) Simplify square roots. Don't forget the $\pm$ sign.

4) Solve for the variable, if needed.

Example 2: Solve the equations using square roots.

$x^2 = 25$

$x^2 - 32 = 0$

$(x-1)^2 = 9$

$(x+1)^2 = 4$

Example 3: Solve the equations using square roots.

$-\frac{2}{3}x^2 + 7 = 3$

$3x^2 - 11 = 2x^2 - 9$

$4(x^2 - 3) = 2x^2 - 6$

Example 4: Solve the equations using square roots.

$(x - 3)^2 = 2$

$2(x - 1)^2 + 1 = 9$

$1/5(x - 1)^2 + 3 = 7$

Radical Review and Factor Review

*Name:*_____

Radical Review - ***Simplify the expression. NO DECIMALS***

1.) $\sqrt{147}$ 2.) $\sqrt{60}$ 3.) $\sqrt{63}$ 4.) $\sqrt{32}$

5.) $\sqrt{12}$ 6.) $\sqrt{45}$ 7.) $\sqrt{125}$ 8.) $\sqrt{24}$

Factor Review

1.) $4x^2 - 12x$ 2.) $3x^2 - 6x$ 3.) $x^2 - x$

4.)$x^2 + 19x + 90$ 5.) $x^2 - 16x + 55$ 6.) $x^2 + 4x - 12$

7.) $5x^2 + 10x + 20$ 8.) $4x^2 - 4x - 8$ 9.) $5x^2 - 30x + 40$

10.) $3x^2 - 13x + 12$ 11.) $15x^2 - x - 2$ 12.) $5x^2 + 19x + 12$

13.) $16x^2 - 9$ 14.) $25x^2 - 121$ 15.) $4x^2 - 81$

16.) $81x^2 - 198x + 121$ 17.) $16x^2 - 40x + 25$ 18.) $49x^2 - 56x + 16$

Chapter 5 Standardized Test Prep

1. The range of the function $f(x) = |x + 5| - 2$ is given by

   A. $(-\infty, 2]$ B. $[-2, \infty)$

   C. $(-\infty, 5)$ D. $[5, \infty)$

   D.

2. If $f(x) = (x + 9)^2 - 4$, which of the following is true?

   A. The vertex is (9, -4)
   B. The y-intercept is -4
   C. The function is one to one.
   D. The graph has two real roots

3. Simplify: $\sqrt{-40}(\sqrt{-64} + \sqrt{-2})$

   A. $-16\sqrt{10} + 4i\sqrt{5}$ B. $-16\sqrt{10} + 4\sqrt{5}$

   C. $16i\sqrt{10} + 4i\sqrt{5}$ D. $-16\sqrt{10} - 4\sqrt{5}$

4. Find all roots for $y = x^2 + 4x + 20$

   A. {2, -6} B. $\{-2 \pm 2i\sqrt{5}\}$

5. Which are the x-intercepts of $f(x) = 6x^2 + 10x = -2$?

A. $\left\{\frac{-5 \pm \sqrt{13}}{6}\right\}$ B. $\left\{\frac{-5 \pm \sqrt{13}}{12}\right\}$

C. $\left\{\frac{-10 \pm \sqrt{13}}{6}\right\}$ D. $\left\{\frac{-5 \pm \sqrt{37}}{6}\right\}$

Appendix C: Two Analogies for Composite Functions

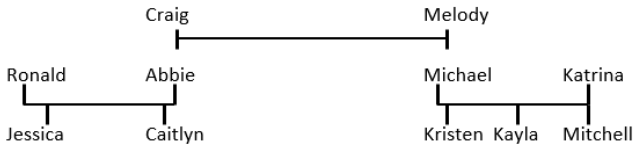
M&M Composition Worksheet



Function	Shell f( )	Chocolate g( )	Peanut x	M & M f(g(x))
$f(x) = x^2 - 3$ $g(x) = x + 1$				
$f(x) = 2x$ $g(x) = x + 5$				
$f(x) = x^2 + 2x - 3$ $g(x) = x - 1$				
$f(x) = x + 1$ $g(x) = x^2 - 3$				
$f(x) = 4x - 1$ $g(x) = x^2 - 2x - 4$			3	f(g(3))

Family Tree Composition Worksheet

Michael and Katrina are the parents of Kristen, Kayla, and Mitchell.



We will use the following notation to describe relations in the family tree.

$m(x)$ means "the mother of x" (including mother-in-law) so m(Michael) is another name for "Melody."

$f(x)$ means "the father of x" (including father-in-law) so f(Ronald) is another name for "Craig."

$s(x)$ means "the sister of x" (including sister-in-law).

$b(x)$ means "the brother of x" (including brother-in-law).

Use the function notation and the family tree to determine the following family members.

1. f(Jessica) = _____

2. m(Kristen) = _____

3. s(Caitlyn) = _____

4. b(Kayla) = _____

5. f(Mitchell) = _____

6. s(Abbie) = _____

7. f(s(Ronald)) = _____

8. s(f(Caitlyn)) = _____

9. m(m(Mitchell)) = _____

10. f(f(Mitchell)) =_____

11. Does m(f(Jessica)) = f(m(Jessica))? How do you know?

12. Does m(s(Caitlyn)) = s(m(Caitlyn)? How do you know?