

ELEMENTARY TEACHER CANDIDATES' CONNECTIONS BETWEEN MATHEMATICS
AND LITERACY AND THE CONTEXTUAL FACTORS THAT ENCOURAGE
CONNECTION-MAKING

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Curriculum, Instruction, and Teacher Education – Doctor of Philosophy

2022

ABSTRACT

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Elementary teacher candidates (TCs) must learn to teach many subject areas. Although some mathematics education researchers have framed elementary teachers' knowledge as a deficit (i.e., lack of depth of mathematics knowledge), this dissertation considers elementary teachers' broad knowledge as a strength. Many elementary teachers and TCs feel anxious about teaching mathematics, but more confident in teaching other subjects, such as literacy. By identifying similarities between the teaching and learning of two subjects, they can draw on their knowledge of teaching other subjects to teach mathematics in a conceptually oriented, inquiry-based way. This case study of a cohort of elementary TCs taking concurrent mathematics and literacy methods courses sought to learn more about their connection-making by asking two questions: (a) *What connections between subject areas, if any, do elementary TCs enrolled in concurrent literacy and mathematics methods courses identify?* and (b) *How do the contexts in which they are learning to teach encourage or limit the opportunities to make connections across subject areas?*

To answer the first question, I developed a conceptual framework of types of connections between mathematics and literacy, based on the research literature. This framework includes integrated curriculum, language as a basis for learning, and similarities in teaching and learning. I generated data through participant observations of class sessions and focus group discussions and analyzed the types of connections the TCs made using my framework. They identified a

variety of connections between mathematics and literacy, with the two most frequent categories being about the role of reading in learning mathematics and similarities in pedagogy.

To analyze the conditions which supported their connection making, I conceptualized the two methods courses as separate, but overlapping, communities of practice, and the focus group discussions as boundary encounters between them (Wenger, 1998). The focus groups, as boundary encounters, enabled TCs to identify a larger number of boundary objects (i.e., connections), as well as make richer connections. This took place through two types of knowledge brokering: brainstorming to identify boundary objects, and collaborative brokering, in which multiple participants contributed knowledge from other courses or experiences to collectively make sense of similarities or differences across the two subjects. In addition, my participation in collaborative brokering during the second focus group discussion suggests that TCs need the support of a more experienced knowledge broker to support their connection-making in order to go beyond surface-level similarities.

These findings suggest that, in order to make connections that would enhance their mathematics teaching, elementary TCs need intentionally created spaces and the support of an instructor who is familiar with the teaching and learning of more than one subject area. This has implications for the structure of elementary teacher preparation programs, as well as the background and/or professional development of mathematics teacher educators who work with elementary TCs.

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ACKNOWLEDGEMENTS

I want to thank the teacher candidates (now teachers!) who allowed me to learn more about their thinking across subject areas, as well as the course instructors who so graciously allowed me into their (virtual) classrooms. I also want to thank the teachers and staff of Triad Elementary. You all were part of making me the teacher (and researcher) I am today.

Thank you to my advisor and dissertation chair, Dr. Amy Parks, and the rest of my committee, Drs. Corey Drake, Laura Tortorelli, and Jennifer VanDerHeide. Although we were not able to meet and talk about this work as often as normally (the perils of dissertating during a pandemic!), I am grateful for the time you took to read my work and give feedback that helped me clarify my thinking and improve my writing. To Amy, I appreciate all the support you have given me over the years, including the time during my first year when I stopped by your office and asked you to tell me I was a competent person who could do things. You did, and I am, partly because of the way your feedback pushed me to think more deeply about my work.

I could not have completed this dissertation without the support of my fellow doctoral students. Learning from one another and knowing that I am not alone in this journey has made all the difference! Thank you to the members of MLRG and the Math Ed Writing Group (MEW-G, as Rileigh called it), especially David, Sheila, Brady, Saul, Rileigh, and my conference buddies, Katie and Kristin. Although you may not have realized it, your steady participation in the math ed community supported inspired me to keep going. Also, to Brent, JoAnne, and Sinead, we survived a bizarre, remote fourth year together. You kept me grounded while dissertating in a pandemic and I'm so glad I've shared this journey with you!

Finally, I want to thank my family, who have told me how proud they are of my accomplishment, even if it means calling me “Doctor Sister” now, after swearing they wouldn’t! And most of all, thank you to my husband, Kevin, who encouraged me to apply to grad school, willingly moved to another state, and put up with all the craziness that comes with a spouse’s dissertation!

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CHAPTER 1: INTRODUCTION

Shifting elementary mathematics instruction from traditional lecture-based methods to inquiry-based and conceptual learning is both an academic and personal concern for me. My memories of mathematics in elementary school are of repeated drills and timed tests. Although I was good at carrying out memorized procedures, recalling math facts from memory was difficult, and in fact, as an adult, I find myself using mental math strategies on some basic math facts, either because I still haven't memorized them, or because I don't trust my own recall of facts after so many years of using an inefficient counting strategy. Once I got to a point in my school career where teachers stopped testing the basic math facts, I excelled in mathematics. The focus on memorizing procedures continued into high school, where I stubbornly insisted that I didn't need to be in class to learn algebra; I could learn it from the book. When my algebra teacher would not allow me to take Algebra I as an independent study to solve a scheduling conflict, I spent the year reading novels in the back of the classroom, while still getting As on all the tests. I must have driven my teacher crazy!

In my teacher preparation program, I went into my "Mathematics for Elementary Teachers" course with the perception that mathematics was about memorizing a bunch of unrelated formulas and procedures, an idea that was quickly challenged. In that class, I made the amazing discovery that mathematics makes sense! I don't need to memorize area formulas for a bunch of different shapes; I can derive them from the area of a rectangle! The Pythagorean theorem $a^2 + b^2 = c^2$ is about the area of actual squares on the sides of triangles! Although this feels amusing to me looking back now, I had never experienced the kinds of mathematics learning that focus on making sense of mathematics.

Making this shift in mathematics instruction in U.S. schools has been a focus of mathematics educators for many years (NCTM, 2000). Despite these efforts, much of mathematics instruction in elementary grades continues to be based on rules and procedures, rather than conceptual understanding of mathematics (NCTM, 2020). In part, this has happened because many teachers rely on their own experiences with learning to inform their teaching – they teach the way they were taught (Ball & Cohen, 1999), and for many teachers, their experience was similar to mine: a focus on memorizing formulas and procedures without understanding how they work, getting correct answers quickly, and completing long pages of calculations for drill and practice.

As a result of my epiphany in teacher preparation that mathematics makes sense, I wanted to teach mathematics to my own students in a way that focused on sense-making and conceptual understanding. I was confident in my ability to do this and, reflecting on my years in a 3rd grade classroom, I think I did reasonably well at teaching in this way. I used the district-provided curriculum but supplemented with other materials when I felt that the published curriculum focused too much on procedural understanding. I avoided teaching “rules” that bypassed understanding. What I didn’t realize is that most of my colleagues were not teaching mathematics in this way. In a discussion about a newly implemented curriculum, I had noted that some of the lessons were fine, but some were really bad, so I created my own. My principal replied that not everyone recognizes which lessons are not good, or feels comfortable in creating their own mathematics lessons.

Elementary teachers teach multiple subject areas, but most feel better prepared or more confident teaching some subjects than others. Mathematics tends to be one of the subjects that elementary teachers feel least comfortable teaching (Buss, 2010; Gerde et al., 2018; Wilkins,

2010). Much of this discomfort can be attributed to elementary teachers' feelings of anxiety towards mathematics and teaching mathematics (Hadley & Dorward, 2011; Wood, 1988). Experiences such as an overemphasis on right answers, fear of making mistakes, and timed tests were factors that teachers report as reasons for their anxiety (Harper & Daane, 1998). Despite the fact that rule-based instruction was a major cause for these teachers' anxiety, elementary teachers with high levels of mathematics anxiety are more likely to reproduce these practices than elementary teachers with lower anxiety (Bursal & Paznokas, 2006; Swars et al., 2008). Students whose teachers experience mathematics anxiety are more likely to have lower mathematics achievement and experience mathematics anxiety themselves (Beilock et al., 2010; Karp, 1991). Teachers with more positive attitudes towards mathematics tend to teach in ways that support students' conceptual understanding, such as learning why procedures work and making connections among mathematics topics (Hadley & Dorward, 2011; Karp, 1991).

As I began to pay more attention to the ways that my colleagues talked about teaching mathematics, I realized that this was true for many of them. They were much more confident teaching literacy than mathematics. This was true even when our school was shifting from a basal reading series to a balanced literacy approach. Although this was a radical shift in instructional practices that required learning a lot of new information and ways of teaching, my colleagues still felt more confident in their ability to teach literacy than mathematics. This is a pattern that is documented in research as well as my personal experience. In contrast to their feelings towards teaching mathematics, elementary teachers report reading and language arts as the subjects they feel most comfortable teaching (Gerde et al., 2018; Wilkins, 2010). Elementary teachers are less likely to have had negative experiences with reading and language arts and are more likely to have experienced teaching that focused on deep comprehension of texts.

In elementary education, we encourage teachers to identify students' strengths and teach in ways that draw on those strengths. If literacy teaching is a (perceived) strength for elementary teachers, I began to wonder how they might draw on those strengths to teach mathematics in a way that focuses on sense-making and conceptual understanding. In my own classroom, I had experimented with using structures typically associated with literacy in my mathematics instruction, such as workshop models (Atwell, 1998; Calkins, 1994), The Daily Five (Boushey & Moser, 2006), Four Blocks (P. M. Cunningham et al., 1999), and other frameworks for organizing instruction. Around the time I was applying to graduate school, a book and an article that I discovered prompted me to begin thinking about other types of connections between mathematics and literacy. The first was a report on adapting Reciprocal Teaching, a reading comprehension strategy, to use in solving mathematics problems (Meyer, 2014; Reilly et al., 2009). I had used Reciprocal Teaching in some of my reading interventions with my students, so I was intrigued by the idea of using it in mathematics. The second was *From Reading to Math: How Best Practices in Literacy Can Make You a Better Math Teacher*, a book by Maggie Siena (2009). Siena draws parallels between mathematics and literacy learning, such as the role of decoding symbols and becoming fluent in reading and computation, as well as teaching strategies such as creating a print-rich/math-rich environment, using a workshop model, and similarities in assessing literacy and mathematics. These two pieces were key in my decision to study how to make mathematics teacher education more strengths-based by drawing on other subject areas. A few studies have taken this strengths-based approach in science, a subject that elementary teachers also report feeling less confident in teaching (Buss, 2010; Wilkins, 2010). These studies supported teachers in using literacy skills and teaching methods in science classes, and they found that drawing on literacy in this way increases teachers' confidence in teaching science

(e.g., Akerson & Flanigan, 2000; Baker & Saul, 1994; Dickinson & Young, 1998; Gerde et al., 2018).

Based on this work in science education, it seems likely that the same would be true for mathematics; however, the way that teacher education is typically structured is unlikely to promote these types of connections across subject areas. Most learning opportunities for teachers are divided by subject areas, including university courses, professional development programs, and journals for teachers, with little communication across those subject area divides. DeLuca, Ogden, and Pero (2015) stated that this separation means that learning opportunities either tend to ignore more general pedagogical concerns, such as assessment, social justice issues, or educational philosophies, or attend to them in ways that feel redundant to practicing and prospective teachers. Frykholm and Glasson (2005) pointed out the importance of situativity in teacher learning. The fragmentation of knowledge in traditional separate learning opportunities encourages teachers to maintain those separations, rather than make connections across subject areas. Because they teach multiple subject areas, elementary teachers and teacher candidates are better positioned to make these kinds of connections across subject areas than secondary teachers and teacher candidates who specialize in one or two subject areas. Given that elementary teacher education is not structured to promote connections in pedagogy across subject areas, are teachers and teacher candidates making these connections despite the subject-area separation in learning opportunities, and if so, how?

For this dissertation, I examined the ways that elementary teacher candidates (TCs) in a teacher preparation program think about connections in learning to teach mathematics and literacy. To guide this inquiry, I asked the following research questions:

1. What connections between subject areas, if any, do elementary TCs enrolled in concurrent literacy and mathematics methods courses identify?
2. How do the contexts in which they are learning to teach (i.e., separate subject-area methods courses, elementary classroom placements) encourage or limit the opportunities to make connections across subject areas?

This dissertation is a case study (Dyson & Genishi, 2005; Stake, 2005) of elementary teacher candidates taking concurrent mathematics and literacy methods courses as a cohort, and ways that they make connections across subject areas. I draw on communities of practice (Wenger, 1998) to make sense of the way that elementary TCs (and teachers) are positioned as members of multiple subject-area education communities of practice, the ways that they connect and move ideas among these communities of practice, and the contexts that encourage these connections. To understand the types of connections between mathematics and literacy that are made by TCs in this study, and education researchers more broadly, I developed a conceptual framework of types of connections based on my data and a literature review of connections between mathematics and literacy. I used this framework to analyze the types of connections that the TCs in this study made. Findings from this case study will help elementary teacher educators understand some of the ways that TCs might see connections between mathematics and literacy, and the conditions that encourage TCs to notice those connections.

Overview of Chapters

In Chapter 2, “Connections”, I define connections and introduce my conceptual framework for types of connections between mathematics and literacy, then review the literature on the types of connections TCs and practicing teachers make using that framework.

Chapter 3, “Theoretical Framework,” describes the theory of communities of practice and how it applies to this dissertation, focusing particularly on the boundaries between communities.

In Chapter 4, “Methodology and Methods,” I describe the case study methodology I chose for this dissertation, the context and participants, and the methods for data collection and analysis.

Chapter 5, “Types of Connections,” examines the findings from my first research question, “What connections between subject areas, if any, do elementary TCs enrolled in concurrent literacy and mathematics methods courses identify?” I analyze the types of connections the TCs made using the conceptual framework from chapter 2.

Chapter 6, “The Role of Knowledge Brokers in Making Connections,” is an analysis of elements of the contexts in which the TCs were learning to teach that encouraged or limited opportunities to make connections between mathematics and literacy teaching and learning. Using concepts of boundary encounters, boundary objects and knowledge brokers, I answer research question 2, “How do the contexts in which they are learning to teach (i.e., separate subject-area methods courses, elementary classroom placements) encourage or limit the opportunities to make connections across subject areas?”

In Chapter 7, the conclusion, I discuss the implications of this study for teacher preparation and share some personal reflections on how this work will inform my future teaching and research.

CHAPTER 2: CONNECTIONS

Connections can be defined in many ways. It can mean things joined together, logical links between two things or ideas, or even social, professional, political, and commercial relationships (Merriam-Webster, n.d.). In the scholarly literature, as well, there are multiple variations on types of connections between mathematics and literacy, as well as a variety of genres, including reports of empirical studies, conceptual pieces exploring connections between the two subjects, and articles for teachers on how to connect mathematics and literacy. To make sense of this variety, I developed a conceptual framework for the types of connections. In brief, there are three categories of connections in the literature: (a) curriculum integration, (b) language as a basis for learning mathematics, including using children's literature, and (c) similarities in teaching and learning literacy and mathematics. In the first section of this chapter, I will elaborate on the conceptual framework, drawing broadly from the various genres of literature to illustrate the types of connections between mathematics and literacy that scholars have made. In the second section, I will more closely examine the empirical research on teachers' connections between mathematics and literacy to situate this dissertation.

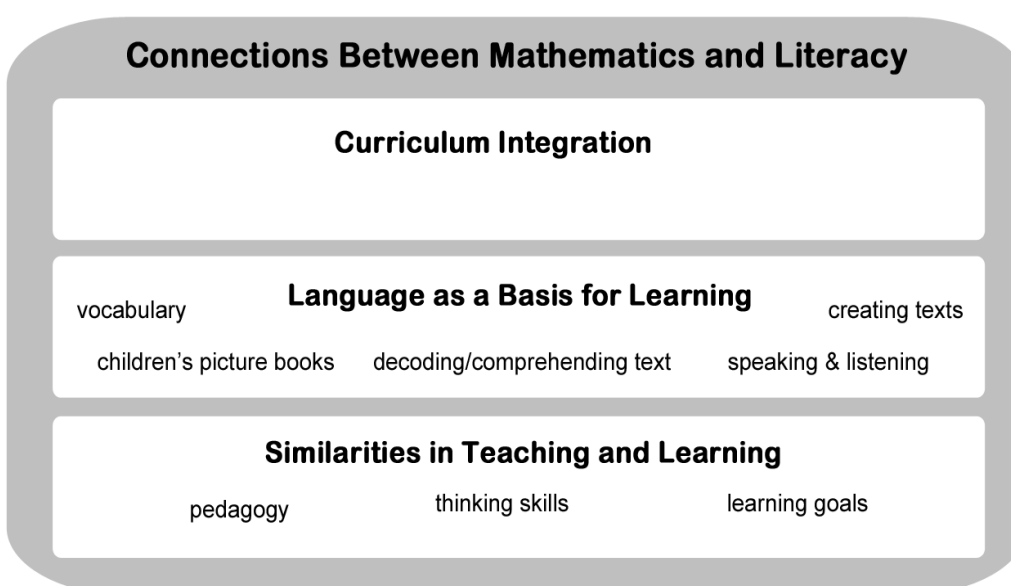
Conceptual Framework: Types of Connections

This framework was developed during my initial analysis of data, using an iterative process of coding data and reading scholarly literature. Because I take a sociocultural view of knowledge (i.e., it is constructed by people), I want to acknowledge that this framework is only one way of considering types of connections among subject areas, and that others may bring a different perspective on types of connections. I also want to acknowledge the messiness of categorization. The categories in a framework are often not as clear-cut in practice where they can overlap or have blurry boundaries, but they can be used as a pragmatic way to think and talk

about connections. Figure 1 is a visual representation of the categories and subcategories in the framework. The three main categories of connections are curriculum integration, language as a basis for learning, and similarities in teaching and learning, and are represented by the smaller rectangles within the larger concept of connections, with subcategories represented as text within the categories. In the following sections, I will define and give examples of each category.

Figure 1

Conceptual Framework: Types of Connections Between Mathematics and Literacy



Curriculum Integration

Curriculum integration, like *connections*, is a phrase that has many meanings in scholarly literature, and there is no agreed-upon definition. For the purposes of this framework, I define curriculum integration as any type of learning that uses more than one subject area and draws on the unique ways of knowing of each discipline. This can take many forms, including interdisciplinary learning, thematic teaching, cross-curricular learning, transdisciplinary study, project-based learning, and others (e.g., Loughran, 2005; Parker, Heywood, & Jolley, 2012; Zhou & Kim, 2010). Although some approaches have been criticized for ignoring disciplinary

ways of knowing by emphasizing overarching thinking skills such as reasoning and problem-solving, or by equating forms of inquiry that are based on very different assumptions, (Parker et al., 2012), advocates of integrated curriculum insist that it is possible to balance different ways of knowing with making connections across disciplines. For example, Frykholm and Glasson (2005) argued for making connections between mathematics and science that are based on the practices of each field, as well as the experiences of students. With integrated curriculum, each discipline brings a unique lens for examining a topic that, when used together, can create a more holistic, complete understanding (Heimer & Winokur, 2015; Parker et al., 2012; Zhou & Kim, 2010).

Language as a Basis for Learning

A second way to understand the connections between mathematics and literacy is to regard all learning as based in language (Fisher & Ivey, 2005; Prendergast et al., 2019). In other words, we learn content, including mathematics, by making meaning through reading, writing, speaking, and listening. Students must engage with mathematical texts, whether reading lengthy questions, examining a graph, or creating their own mathematical representations (Draper & Siebert, 2004). Students use mathematical language to communicate their thinking and develop mathematical practices (A. E. Adams et al., 2015; Armstrong et al., 2018; Yilmaz & Topal, 2014), and reading and writing about mathematics helps learners to make sense of new concepts (Caputo, 2015; Drake et al., 2001).

Reading: Decoding and Comprehending Math Text

Mathematics text can be difficult for students to read. It can contain unfamiliar vocabulary, unknown symbols including implied symbols in $4x$ (multiplication) and $4\frac{1}{2}$ (addition), longer and more complex sentences, more words and concepts per paragraph than

other nonfiction text, and non-prose elements (e.g., graphs, equations, diagrams, etc.; J. Adams, 2011; Draper & Siebert, 2004; Siena, 2009; Thompson & Rubenstein, 2014). As a result, students need explicit instruction in how to read and create mathematics texts (Fogelberg et al., 2008; Lemley et al., 2019). Disciplinary literacy approaches support students' reading by beginning with the literacy practices of mathematicians, scientists, historians, artists, and so on, and using those practices with students in school (Colwell & Enderson, 2016; Doerr & Temple, 2016; Gillis, 2014). Table 1 shows some examples of comprehension strategies that can be useful for reading mathematics texts.

Table 1

Examples of Recommended Reading Comprehension Strategies

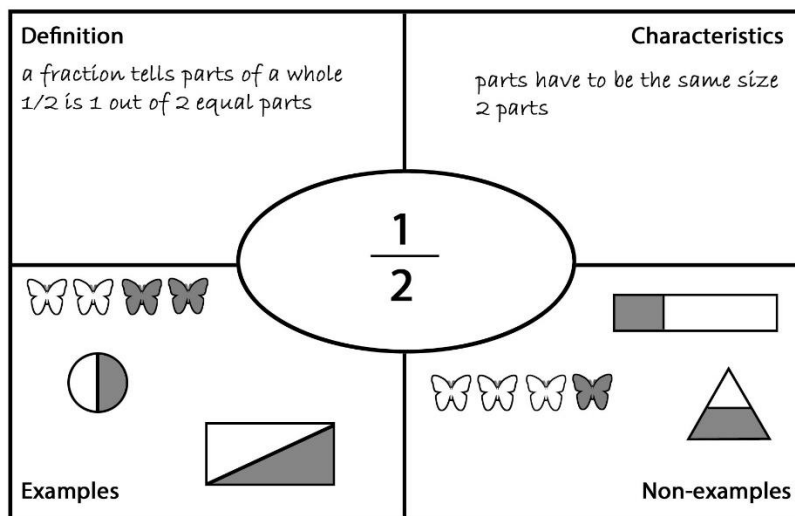
Comprehension Strategy	Supporting Literature
Determining importance	Fogelberg et al., 2008; Halladay & Neumann, 2012; Hoffer, 2012
Monitoring comprehension	Capraro, Capraro, & Rupley, 2012; Doerr & Temple, 2016; Fogelberg et al., 2008; Hoffer, 2012; Siena, 2009; Thompson & Chappell, 2007
Asking and answering questions	Doerr & Temple, 2016; Fogelberg et al., 2008; Hoffer, 2012; Siena, 2009; Thompson & Chappell, 2007
Using language, sentence, and text structure	Capraro et al., 2012; Halladay & Neumann, 2012; Thompson & Chappell, 2007
Making inferences	Capraro et al., 2012; Fogelberg et al., 2008; Hoffer, 2012; Siena, 2009

Vocabulary: Mathematical Language

Vocabulary is critical to reading comprehension, and mathematics vocabulary holds a special challenge, as there are many words used in mathematics that have other everyday meanings (e.g., odd, face, difference, volume) as well as words that have different meanings in different contexts, such as *median* in geometry versus statistics (Schleppegrell, 2007; Thompson & Chappell, 2007) and even small words like *is* used for classification (e.g., a square is a quadrilateral) versus identity (e.g., a prime number is a number that can only be divided by itself and one; Herbel-Eisenmann, Steele, & Cirillo, 2013). Two components of vocabulary instruction that seem well-suited to mathematics are direct teaching of important words and fostering word consciousness, which includes analyzing word parts (Feldman & Kinsella, 2007). For example, a student might notice that an *octagon* has eight sides, and an *octopus* has eight legs, or that the prefixes *kilo-*, *milli-*, *centi-* and so on are used through the metric system of measuring (Thompson & Chappell, 2007). When directly teaching important words, students need to learn the concepts attached to the words (Siena, 2009). Frayer models (Armstrong et al., 2018) and concept sorts (Fogelberg et al., 2008) are two examples of vocabulary learning strategies that emphasize understanding. In a Frayer model, students write the target word in the center circle, then write the definition in their own words, characteristics or facts about the word, examples and nonexamples (see figure 2). In a concept sort, groups of students get a set of words on cards and arrange them in ways that make sense to them, then explain why they grouped the words that way. Word play can also be an effective way to teach mathematics vocabulary. Activities like word associations, exploring word choice in writing, and creating multi-meaning word cards can strengthen students' mathematics word knowledge (Altieri, 2009).

Figure 2

Example of a Frayer Model for One Half



Writing: Creating Math Text

Writing can be a way for students to make sense of mathematics and to explain their thinking. It requires students to organize and clarify their ideas, which supports developing conceptual understanding (Burns, 2004; Drake et al., 2001; Fisher & Ivey, 2005). Examples of students using writing in mathematics include keeping mathematics journals to record their thoughts (Armstrong et al., 2018; Douville et al., 2010), writing their own mathematics problems (Thompson & Chappell, 2007), bringing writing composition skills into mathematics writing (Carter, 2009), as well as more creative writing, such as poetry (Ward, 2005). Sharing that writing also has benefits. Carter (2009) described how having students share their mathematical writing led to students revising their mathematical thinking in ways that did not happen in a more typical mathematics class. For younger learners, including mathematical text as part of the print-rich environment also benefits their mathematics learning (Ruiz et al., 2005).

Speaking and Listening

In addition to reading and writing, speaking and listening can be used as tools for learning mathematics (Thompson & Chappell, 2007; Thompson & Rubenstein, 2014; Yilmaz & Topal, 2014). Speaking and listening in mathematics can include teacher and student think-alouds, in which the speaker talks through their strategies for making sense of the mathematics (Armstrong et al., 2018), and classroom discussions around mathematical concepts, strategies for solving problems, and mathematical reasoning. Discussions support students' conceptual learning of mathematics (Michaels et al., 2008), and many scholars have produced work to support teachers in facilitate discussions (e.g., Chapin et al., 2013; Herbel-Eisenmann et al., 2013; M. S. Smith & Stein, 2011).

Children's Literature in Math

Another way to use language to support mathematics learning is through the use of children's literature in mathematics teaching and learning. This can include using picture books with explicit mathematics content, as well as "mathematizing" other picture books that may not seem to include mathematics at first glance (Hintz & Smith, 2013; J. Marston, 2014). Discovering mathematics embedded in stories demonstrates to students that math is present in everyday life and is used in many different situations (Purdum-Cassidy et al., 2015; Ward, 2005). The use of picture books can make mathematics learning more engaging and fun, showing students the joy and wonder in mathematics (Hintz & Smith, 2013; Prendergast et al., 2019), and providing opportunities for students to study a mathematics topic in a different setting (Fogelberg et al., 2008; Lemonidis & Kaiafa, 2019; Linder & Bennett, 2020; J. L. Smith & Johnson, 1994). For example, teachers can use the book *The Very Hungry Caterpillar* (Carle, 1994) to help students learn counting skills (Hintz & Smith, 2013), or a book such as *The*

Doorbell Rang (Hutchins, 1994) to explore concepts of division as equal sharing (Wohlhuter & Quintero, 2003). Books like these can provide a context for mathematics discussions (Courtade et al., 2013; Hintz & Smith, 2013; Nesmith et al., 2017; Ward, 2005) in which children can use informal, familiar language to explore new mathematics concepts before being introduced to the formal mathematics vocabulary, as well as supporting children's mathematical reasoning and conceptual understanding by providing concrete examples through vivid illustrations (J. L. Marston et al., 2013; Nesmith et al., 2017; Ruiz et al., 2005; Starčič et al., 2016).

Similarities in Teaching and Learning

A third way to understand connections between mathematics and literacy are the similarities in teaching and learning the two subjects. There are several researchers who have explored the similarities in the learning goals for students, the thinking skills and strategies that are used by students learning both disciplines, and the instructional practices used by teachers of both disciplines.

Similarities in Learning Goals

Several scholars have investigated similarities in the learning goals for children in mathematics and literacy. Some scholars compared content expectations in the English language arts and mathematics Common Core State Standards (CCSS) with some also including the NCTM process standards in their analysis (e.g., Carter, 2009; Cheuk, 2012; Thompson & Chappell, 2007; Wohlhuter & Quintero, 2003; Yilmaz & Topal, 2014). Others, often with elementary education backgrounds, described similarities they have noticed in their own or other teachers' classroom practices in the two subjects (e.g., Capraro et al., 2012; Hyde, 2006; Matthews & Rainer, 2001; Ruiz et al., 2005; Siena, 2009; Spillane, 2000; Wohlhuter & Quintero, 2003). Table 2 lists some examples of similarities that have been noted.

Table 2*Similar Learning Goals Across Mathematics and Literacy*

Learning Goal	Mathematics	Literacy
Communicate information	Communicate mathematical thinking coherently and clearly	Write text that conveys information, and present information clearly
Construct arguments with evidence	Construct viable arguments	Cite textual evidence to support conclusions
Use tools strategically	Manipulatives, paper/pencil, calculator, ruler, etc.	Pencil and paper, word process, read digital and print text
Make sense of information	Conceptual understanding of mathematics	Comprehension of text
Fluency with “basic” skills	Accuracy, efficiency, and flexibility with computation and basic number combinations	Accuracy, appropriate rate, and expression with decoding, automatic correct spelling, and grammar
Understand meanings of symbols	Numerals and symbols	Letters and punctuation
Use visuals to convey and understand information	Diagrams, tables, graphs, figures, drawings, etc.	Illustrations, photographs, timelines, charts, etc.

The last two entries in the table (i.e., understanding symbols and using visuals) are especially relevant in the early elementary grades, as children are learning to decode text by matching speech sounds to the letters used to represent them, and also making sense of written numerals and the quantities they represent. Young children also use a combination of illustrations and words to convey meaning to readers, and that can easily be extended to using drawings, diagrams, and so on to convey mathematics as well. Another similarity worth noting is the relationship between sense-making and “basic” skills. In both literacy and mathematics, the “basic” skills are important, but do not define the entire discipline. For both literacy and

mathematics, the goal is understanding and sense-making (i.e., conceptual understanding of mathematics and comprehension of text in literacy), and the basic skills support those goals.

Similarities in Thinking Skills

In addition to examining similarities in learning goals, some scholars have noted commonalities in the thinking skills students use to learn in both subjects. For example, in both subjects, students make sense of new concepts and ideas using prior knowledge and experience (Fisher & Ivey, 2005; Hyde, 2006; Matthews & Rainer, 2001). Spillane (2000) observed that in a fifth-grade teachers' language arts lessons, knowledge was treated as tentative, and students played a role in deciding the validity of knowledge, not only the teacher and textbook. The nature of knowledge in a mathematics classroom should be similar, with students experimenting with solution strategies and using rough-draft thinking to explore mathematical ideas and connections over time (Fogelberg et al., 2008; Halladay & Neumann, 2012; Jansen, 2020; Siena, 2009; Spillane, 2000; Thanheiser & Jansen, 2016).

Making connections and metacognition are two other thinking skills used across subject areas. While reading, students use what they already know about a topic to make different kinds of connections, often described as text-to-self, text-to-text, and text-to-world (Keene & Zimmerman, 1997). In mathematics, students can make similar connections, which some mathematics educators have named math-to-self, math-to-math, and math-to-world (Coffey & Billings, 2008; Fogelberg et al., 2008; Halladay & Neumann, 2012). Metacognition takes place in reading when children monitor their comprehension and use a variety of strategies to “fix-up” their comprehension when needed. Estimating answers to problems and asking whether an answer makes sense given the context of the problem are two examples of metacognition in mathematics learning (Fogelberg et al., 2008; Halladay & Neumann, 2012; Hoffer, 2012; Hyde,

2015). Using common language for these thinking skills can help students apply them across subjects to build conceptual understanding of mathematics and a variety of texts (Halladay & Neumann, 2012; Hyde, 2015; Siena, 2009)

Similarities in Pedagogy

Scholars have also noted similarities in pedagogy across the two subject areas. This includes pedagogy that could be considered more general and used across many subject areas, as well as subject-specific pedagogies that have been adapted to be used in a different subject. Instructional elements such as lesson planning structures, assessment strategies, and differentiation approaches are often similar and can be used across multiple subject areas (DeLuca et al., 2015; Siena, 2009). Reading and writing workshops have become common in elementary classrooms (e.g., Atwell, 1998; Calkins, 1994; Keene & Zimmerman, 1997), and scholars in mathematics education are adapting this model into math workshops (e.g., Hoffer, 2012). The role of children's experiences in and out of school are important in both subject areas. Children need to experience subject matter in order to learn it; in other words, they need to *do* reading and writing, and they need to *do* mathematics (Siena, 2009; Wohlhuter & Quintero, 2003). Connecting these subject areas to children's lived experiences outside of school can enhance their learning (Matthews & Rainer, 2001; Wohlhuter & Quintero, 2003).

Other scholars have adapted reading comprehension strategies, such as KWL charts and reciprocal teaching, as heuristics for problem solving (Hyde, 2006, 2015; Meyer, 2014; Reilly et al., 2009). Reciprocal teaching is a method for supporting children's comprehension of text by focusing on four processes that students use throughout their reading, and take increasing responsibility in using (Palincsar & Brown, 1984). Students predict before reading, question and clarify (i.e., monitor and fix-up comprehension) during reading, and summarize after reading.

Table 3 shows how Reilly, Parsons, and Bortolot (2009) adapted these into a way to make sense of and solve mathematics problems.

Table 3

Reciprocal Teaching in Reading and Mathematics

Reading	Mathematics
Predict Before reading, anticipate what will happen (narrative text) or what information will be presented (informational text).	Predict Identify the question, predict type of mathematics needed and type of answer
Clarify Identify difficulties while reading (e.g., unfamiliar words, losing track of meaning) and self-correct	Clarify Identify known information, unfamiliar terms, and information needed to solve the problem
Question Generate questions about key components of the text	Solve Develop and use strategies to solve the problem
Summarize Briefly retell the plot (narrative text) or state the key ideas (informational text)	Summarize Justify answer and reflect on strategies chosen

Note. Adapted from Reilly, Parsons, and Bortolot, 2009

The students using this heuristic were familiar with reciprocal teaching in reading and using common language across subject areas helped them to understand and remember the heuristic. Hyde (2006, 2015) also used common language to adapt KWL, a popular reading comprehension strategy, for understanding mathematics work problems. KWL stands for Know-Wonder-Learned. Before reading students identify what they know and wonder about the topic and tell what they learned after reading. Hyde adapted this to KWC, “What do I **K**now for sure?, What do I **W**ant to figure out? Are there any special **C**onditions, rules or tricks I have to watch out for?” (p. 22).

I used this conceptual framework while reviewing the empirical research literature on elementary teachers’ and TCs’ connections between mathematics and literacy to identify the types of connections that have been studied. I also used the framework in Chapter 5 to analyze

the types of connections the TCs in this study made between mathematics and literacy. The three main types of connections (i.e., curriculum integration, language as a basis for learning, and similarities in teaching and learning) are present in the literature and the TCs' talk, although there is a difference in emphasis, with the research literature focused nearly entirely on curriculum integration and the use of language in learning mathematics, while the TCs spoke mostly about the similarities in teaching and learning.

Literature Review: Teachers' Ideas about Connections

Most of the literature on connections between mathematics and literacy are conceptual pieces, reports of teacher educators' collaboration across subject areas, or practitioner articles with advice on implementing the connections. There are fewer empirical studies that have investigated the ways that practicing teachers or teacher candidates (TCs) think about connections between mathematics and literacy. I acknowledge that practicing teachers may have different perspectives on teaching than TCs due to their experience. However, there were so few empirical studies on TCs' ideas about connections between mathematics and literacy that I included both practicing teachers and TCs in this review. There were 12 groups of researchers who produced 15 articles that give some insight into the types of connections practicing teachers and TCs make between mathematics and literacy. All the studies except one took place in the context of a professional learning opportunity, including teacher preparation courses for TCs, and university courses and school-based professional development (PD) for practicing teachers. The researcher/facilitator/instructor determined the content and structure of the learning opportunity for teacher preparation courses and university courses for practicing teachers, whereas the PD focused on supporting teacher inquiry into connections between mathematics and literacy. Table 4 shows a summary of the participants, contexts, and types of connections in

these studies. First, I will review what this research reveals about teachers' ideas about connections in the context of instructor-determined learning opportunities, followed by a discussion of the teacher inquiry approach.

Table 4

Participants, Context, and Types of Connections in Research

Authors	Participants	Context	Connection(s)
Boche, Bartels, & Wassilak, 2021	TCs	Integrated TPP	Integrated curriculum
Brand & Triplett, 2012	TCs	Integrated TPP	Integrated curriculum
DeLuca et al., 2015	TCs	Integrated TPP	Integrated curriculum
Doerr & Temple, 2016	PTs	Inquiry-based PD	Disciplinary literacy
Gilles, Wang, & Johnson, 2016	PTs	Inquiry-based PD	Disciplinary literacy
Heimer & Winokur, 2015	TCs	Interdisciplinary curriculum course	Integrated curriculum
Lemley et al., 2019	PTs	University course	Disciplinary literacy
Matthews & Rainer, 2001	PTs	Inquiry-based PD	Similarities in teaching and learning
Phillips, Bardsley, Bach, & Gibb-Brown, 2009	PTs	Inquiry-based PD	Disciplinary literacy
Purdum-Cassidy et al., 2015 ^a	TCs	Mathematics methods course	Children's literature in mathematics
Prendergast et al., 2019	TCs & PTs	Survey	Children's literature in mathematics
Wilburne & Napoli, 2008	TCs	Concurrent literacy and mathematics methods courses	Children's literature in mathematics

Note. TC = teacher candidate; PT = practicing teacher; PD = professional development; TPP = teacher preparation program.

^a This group published four articles from the same study (see also Cooper et al., 2018; Nesmith et al., 2017; Rogers et al., 2015)

Teachers' Connections in Coursework

In the studies situated in coursework for TCs or practicing teachers, researchers reported on two types of connections: integrated curriculum and using children's literature in mathematics. Four studies examined teachers' and TCs' ability to create interdisciplinary

lessons after taking a course or set of courses with an explicit focus on integrated curriculum.

Three groups of researchers analyzed TCs' and practicing teachers' use of children's literature in mathematics. One of those groups published four articles on different aspects of TCs' use of children's books from one study (i.e., Cooper et al., 2018; Nesmith et al., 2017; Purdum-Cassidy et al., 2015; Rogers et al., 2015), and one study was based on a survey of practicing teachers and TCs rather than on coursework.

Connections in Curriculum Integration

Two of the four studies on curriculum integration took place in elementary teacher preparation program that included coursework that integrated across subject areas. One program included methods courses that combined more than one subject area (DeLuca et al., 2015), and the other concurrently enrolled students in a set of two or three subject-specific methods courses in which the instructors collaborated and deliberately made connections across the courses (Boche et al., 2021). Both were part of larger studies comparing integrated teacher preparation programs with more traditionally structured programs. Although they focused mostly on outcomes such as TCs' confidence in their ability to teach multiple subjects or TCs' beliefs about the value of integrated learning, they do offer some insight into TCs' thinking about integrating curriculum. Teacher candidates in DeLuca and colleagues (2015) study reported that the integrated courses "forced [us] to look at things that are common between all subjects" (p.238), such as lesson plan structures and assessment strategies, and that they were able to focus more on aspects of good teaching that cross subject areas. Boche, Bartels, and Wassilak (2021) analyzed TCs interdisciplinary lessons for three types of integration: (a) thematic integration, which uses themes across subject areas to connect them, (b) interdisciplinary integration, in which one subject area is used to support learning in another subject, and (c) full integration, where the

emphasis on two or more subjects is balanced. Categories (a) and (c) are similar to the integrated curriculum in my conceptual framework, while category (b) is more similar to disciplinary literacy in using language as a basis for learning. Boche and colleagues found that TCs mainly planned interdisciplinary integration, using books with social studies or science content in reading lessons, or using writing to support learning in other subjects.

The other two studies on curriculum integration also took place in teacher preparation programs, but focused on a particular course that had an emphasis on interdisciplinary connections. Heimer and Winokur's (2015) study took place in an early childhood teacher preparation program that included a course on interdisciplinary curriculum. They found that the TCs in their program were able to create interdisciplinary units that had some connections between subjects, but those connections were mainly thematic rather than conceptual and TCs had difficulties articulating the connections. Brand and Triplett (2012) reported TCs in their study having similar difficulty in making conceptual connections across subject areas. As part of their program, TCs created interdisciplinary units that included four or more subjects. Brand and Triplett followed up with graduates of their program during their first year of teaching, who reported mostly using reading and writing to support learning in other subject areas, and not the more ambitious integration they had experienced in their preparation program.

These studies illustrate the difficulties of making substantial connections between subject areas, even in settings designed to support such connections. The tendency of k-12 schools to compartmentalize subject areas through separate curriculum materials, separate assessments, and the pressures of time constraints and lack of resources create more barriers to connecting subject areas (Brand & Triplett, 2012; Heimer & Winokur, 2015).

Connections With Children's Literature

Three groups of researchers looked at the ways that practicing elementary teachers and TCs thought about and used children's literature in mathematics instruction. Most of the studies focused on the TCs' or practicing teachers' perception of the value of using children's literature in mathematics, all of them finding that, after participating in a course or PD on using picture books, teachers and TCs had a positive perception (Nesmith et al., 2017; Prendergast et al., 2019; Wilburne & Napoli, 2008). In addition to the study on perception of value, Purdum-Cassidy, Meyer Rogers, Cooper, and Nesmith (2015, 2018) also looked at the ways that TCs used picture books in mathematics lesson planning, including what criteria TCs use for selecting picture book that support mathematical thinking (Cooper et al., 2018), what kinds of questions they planned to ask during the read-aloud of the picture book (Purdum-Cassidy et al., 2015), and how they used the book (e.g., as a context for mathematics, to develop a concept, to use with manipulatives; Rogers et al., 2015). Most of the TCs chose books by mathematics topic, using criteria of accuracy of the mathematics, visual appeal, and meaningful connections between mathematics and real life (Cooper et al., 2018). When planning an interactive read aloud with their chosen books, most TCs planned questions that drew attention to the conceptual understanding of the mathematics (Purdum-Cassidy et al., 2015). Both of these studies indicate that the TCs were able to find significant mathematics content in picture books and connect those books to lessons around that content.

Connections in Teacher Inquiry

In contrast to these studies that looked at teachers' ideas in the context of a pre-developed curriculum, five studies investigated the kinds of connections that teachers make when supported in their own inquiry. Of those five studies, four of them were investigating ideas related to

disciplinary literacy; that is, using the reading, writing, speaking, and listening practices of experts in the discipline to support children's learning. After briefly describing each of the five studies on disciplinary literacy, I will discuss the similarities and differences across the studies.

Phillips and colleagues (2009) and Gilles, Wang, and Johnson (2016) worked with teams of middle school teachers in which at least one teacher had a background in literacy education. The teacher teams in Phillips and colleagues' (2009) study consisted of mathematics teachers, literacy specialists, and special education teachers. They analyzed mathematics standardized tests for the reading demands of the questions, then co-planned lessons in which the mathematics teachers focused on the mathematics learning standards and the literacy specialists looked for opportunities to incorporate literacy strategies. Over time, the mathematics teachers noticed more and more of those opportunities, realizing it was their job to help students transfer those skills across disciplines.

The seventh grade teachers in Gilles, Wang, and Johnson (2016) were organized in a team of a mathematics, science, social studies, and English language arts teacher. Gilles and colleagues positioned these teachers as expert readers in their disciplines and supported teachers in examining their own use of reading strategies in various genres of text. As a result of this collaborative inquiry, the four teachers chose to use a common strategy of making connections with their students, with variations for each subject area. The mathematics and social studies teachers focused on connecting their subjects to real life; the science teacher connected new learning with past learning; and the English language arts teacher connected across subject areas by asking students to write poems using vocabulary from the other content areas.

Doerr and Temple (2016) worked with two sixth grade teachers with elementary education degrees. They tracked the teachers' changing ideas about connections between

mathematics and literacy over a four-year PD. At first, the two teachers viewed the text in their mathematics book as an obstacle to students' learning, and mostly summarized it for students or ignored it. As one teacher began to wonder about and investigate what made the mathematics text so difficult for students, they both began integrating general reading strategies into their mathematics lessons to support students' reading of the text, noticing that some strategies seemed to work better for mathematics text than others. By the end of the four years, they were purposefully selecting strategies to support students' learning *from* the text, rather than just supporting their reading *of* the text.

Lemley and colleagues (2019) also worked with elementary teachers, ranging from kindergarten through grade 6, in the context of graduate-level coursework. The six elementary teachers read literature about disciplinary literacy and interviewed disciplinary experts, defined as teachers or professors who taught that discipline. The teachers each wrote a paper describing the disciplinary literacy practices and created lesson plans that incorporated those practices. Lemley and colleagues found that the teachers developed a better understanding of disciplinary literacy practices, as evidenced by their papers, but the integration of those practices into lesson plans was mixed, with some teachers using disciplinary texts with general reading strategies and others applying specific disciplinary practices. Lemley and colleagues conjectured that the elementary teachers' lack of expertise in the disciplinary practices contributed to their difficulty in using them in lesson plans.

In contrast to these four studies, where the researchers chose the type of connection between subject areas (i.e., disciplinary literacy), Matthews and Rainer (2001) specified the subject areas to connect but left the types of connections to the teachers as they explored literacy and mathematics learning. They described a professional development workshop in which

teachers explored connections between literacy and mathematics while developing learning frameworks. At first, the teachers created separate lists of mathematics and literacy skills, but as they continued to work, they began to notice similarities in teaching and learning across the two subject areas, such as concern with both conceptual understanding and skills, the importance of children's prior knowledge, and constructing understanding of texts and mathematical concepts.

One major difference across these studies is the way the teachers were positioned. Phillips and colleagues (2009) positioned the middle school teachers as experts in their disciplines that each contributed unique strengths to co-planning, and who learned from one other in the process. Gilles and colleagues (2016) positioned the middle school teachers as expert readers in their discipline who could identify strategies they used that would be helpful to students. Matthews and Rainer (2001) saw the teachers as co-explorers of what it means to integrate mathematics and literacy. Doerr and Temple (2016) deliberately chose teachers with elementary backgrounds, conjecturing that those teachers could draw on their repertoire of reading strategies to support mathematics learning. They also described the ways their own understanding of reading in the content areas changed as a result of the teachers' exploration. In contrast, Lemley and colleagues (2019) positioned elementary teachers as not-disciplinary-experts (by asking them to interview "experts") and used that perceived lack of expertise to explain the differences in implementation of disciplinary literacy strategies.

Despite Lemley and colleagues' deficit stance on elementary teachers' knowledge, all of these studies show that teachers and TCs do make connections across subject areas, whether that is thematic connections across disciplines, using children's books to teach mathematics, or supporting children's reading of mathematics text by drawing on their knowledge as reading teachers. One drawback to this body of literature is that the literature on TCs' connections is

limited to examining plans for interdisciplinary lessons or for using children's books in mathematics. All of the inquiry-based studies were of practicing teachers. Another limitation is that, except for Matthews and Rainer's (2001) study, the types of connections were chosen by the researchers. Even the inquiry-based PD focused on one type of connection – disciplinary literacy. Matthews and Rainer provided support and occasional 'nudges' to look more closely at some of their ideas, but the teachers themselves developed their frameworks by making their own connections between mathematics and literacy. This study was the only one where teachers made connections by noting the similarities in teaching and learning. This raises an interesting question about the role of the setting in which the teachers and TCs were learning. Doerr and Temple (2016) noted:

The teachers in our study did have literacy knowledge and expertise; yet, prior to our research project, they did not see the relevance of reading for learning mathematics. This suggests that having reading expertise as an available resource may not be enough for mathematics teachers to develop a view of reading as necessary for mathematics learning as long as such a view conflicts with their prior experiences and beliefs about learning mathematics.” (p. 28)

The question that lingered for Doerr and Temple is why, if they had sufficient content knowledge of literacy and mathematics, did the teachers not make those connections before participating in the PD. This dissertation adds to our understanding of the types of connections that TCs make between mathematics and literacy and examines the role of the context in making connections using Wenger's (1998) idea of boundary practices of communities of practice. In the next chapter, I will describe Wenger's theory and how it is used in this dissertation.

CHAPTER 3: THEORETICAL FRAMEWORK

In cognitive views of learning and knowledge, knowledge consists of mental representation stored in the mind, with different perspectives considering varying degrees of the impact of social context on learning (Gee, 2013). In contrast, in sociocultural theories, knowledge is seen as “relationships between individuals (with both minds and bodies) and physical, social, and cultural environments” (Gee, 2013 p. 372). This knowledge is co-constructed through social interaction, with language as the primary means by which we construct this knowledge (Vygotsky, 1978). We use language to make sense of the world and build a shared understanding of what is “true” (Gee & Handford, 2012), to construct identities for ourselves and others (Gee, 2000), to express social relationships and social values (Halliday & Webster, 2003), and to shape the world around us (Erickson, 2004), among many other purposes for language. In this dissertation, I ground my work in sociocultural understandings of learning, and draw on communities of practice to understand the ways in which interactions among people support TCs in making connections between subject areas.

Communities of Practice

Sociocultural perspectives view learning as participation in a community of practice (e.g., Lave, 1996; Rogoff, 1994; Vygotsky, 1978; Wenger, 1998). A community of practice is a group of people who know how to participate in shared practices, using common language (Greeno & Engeström, 2013). Learning is seen as the process of becoming a full participant in a community of practice, of becoming a certain type of person. Newcomers to the group begin as legitimate peripheral participants in the community of practice (Lave & Wenger, 1991). They gain an overall view of what it means to be a member of that community of practice and begin participating in some of the practices. More experienced members serve as exemplars of what

the newcomers are becoming (Lave, 1996). In an ethnographic study of the apprenticeship of Vai and Gola tailors, Lave described the ways that apprentices learn by observing master tailors and being assigned portions of the work that increase in complexity as they become more expert at making garment (Lave & Wenger, 1991). Because they all worked together in the same workshop, new apprentice tailor learned from the examples of the more expert apprentices as well as the master tailors.

In teacher education, this is a little bit more complicated. The goal of methods courses is to support TCs in learning the practices of elementary teachers; however, what is happening in methods courses is not elementary teaching. At best, it can only be an approximation, an introduction to the community of practice of elementary teachers, similar to the way claims processors in Wenger's (1998) vignette participate in an initial training class to be introduced to the practices of claims processors before joining in the actual work. In a best-case scenario, the instructors of methods courses who were previously elementary teachers are expert members of the elementary teaching community of practice and are able to draw on that background to give TCs a more accurate approximation.

Using Greeno and Engeström (2013)'s metaphor of conceptual domains as a space and learning as moving around in that space, I am conceptualizing subject-area methods courses as communities of practice that are not elementary teaching but are closely related and exist in the boundaries of an elementary teaching community of practice, mediating the entrance of newcomers into the community. For the purposes of this study, I am focusing in on the mathematics methods course community of practice and the literacy methods course community of practice, where the shared "practice" of each community is talking about and practicing how

to teach mathematics and literacy, respectively, with the course instructors and I as the more expert members of those communities, and the TCs as novices.

Connections Across Communities of Practice: The Problem of Situated Learning

In contrast to cognitive views of learning in which students learn bits and pieces of knowledge that they then put together to create a whole that is abstract and de-contextualized, sociocultural views see all learning as situated in the particular context in which it is learned. There is no such thing as de-contextualized learning or knowledge (Billett, 1996; Lave & Wenger, 1991). For example, Boaler (1998) studied two schools with similar student demographics, but different approaches to mathematics instruction. One school took a traditional, de-contextualized approach to mathematics teaching; the other, a problem-based approach. The students in the traditional approach were not able to apply their mathematics skills in situations that were not similar to the textbook mathematics they had experienced. In contrast, the students at the problem-based approach were able to use their mathematics skills in a variety of contexts by analyzing the situation and using the knowledge they had to make sense of the situation, which is how they had learned the mathematics. This study demonstrated how the mathematics in the traditional setting, which many consider to be abstract and de-contextualized, is much more tied to the conditions in which it was learned. This leads to the question, if all knowledge is situated in the context in which it is learned, how does knowledge move between communities of practice, rather than remaining solely within the community where it was generated?

Boundaries of Communities of Practice

Sociocultural theorists conceptualize transfer as recognizing similarities among contexts where knowledge can be applied (Greeno & Engeström, 2013; Griffin, 1995), and this takes

place in the boundaries between communities of practice. There are four constructs that are important in understanding the role of boundaries in making connections across communities of practice: boundary objects, boundary encounters, boundary practices, and knowledge brokers.

Boundary objects refer to things that link communities of practice together, but can sometimes be used in very different ways by each community (Yakhlef, 2007). Boundary objects can be physical objects such as artifacts and documents, but also include concepts and ideas (Star, 2010; Wenger, 1998). In this dissertation, instructional practices of elementary teachers function as boundary objects in the methods course communities of practice, as they are used as objects of discussion and rehearsal, rather than actually being used as practices of the community.

Boundary encounters are the spaces where people and/or objects from different communities interact (Wenger, 1998). Lam (2018) refers to these as “third spaces” between communities of practice that are (more) free of the constraints of the individual communities and that can make connections across the communities more possible. The focus group discussions in this dissertation were a sort of boundary encounter between the communities of mathematics methods and literacy methods. An important distinction between the focus groups in this study and Wenger’s and Lam’s conceptualization of boundary encounters is that, rather than being a meeting among members of each community, the TCs were already members of both communities, and the focus group created a space to bring the ideas of both communities together.

Related to boundary encounters are boundary practices, which Wenger (1998) defined as the practices that develop during boundary encounters, especially boundary encounters that reoccur over time. Wenger used training classes as an example of a boundary practice between a

community of practice and the rest of the world. Elementary teacher preparation programs and subject-area methods courses are intended to function as a boundary practice of elementary teaching. One danger of a boundary practice is that it may become separated from the original communities and become a community of practice of its own. Although some scholars have conceptualized teacher education and elementary schools as separate communities of practice (Canipe & Gunckel, 2020; He, 2009), I am conceptualizing the subject-area methods courses in this dissertation as boundary practices that have not (yet) become completely separated from the larger community of elementary teaching, but are disconnected from each other enough to think of them as separate from other subject-area methods communities.

Finally, knowledge brokers are the people who can move elements between communities of practice. Knowledge brokers are members of multiple communities of practice, and their role has been described as translating elements between communities (Kimble et al., 2010; Wenger, 1998; Yakhlef, 2007). As Wenger describes it:

The job of brokering is complex. It involves processes of translation, coordination, and alignment between perspectives. It requires enough legitimacy to influence the development of a practice, mobilize attention, and address conflicting interests. It also requires the ability to link practices by facilitating transactions between them, and to cause learning by introducing into a practice elements of another (p. 109).

Adding to the complexity of brokering is the need to maintain a position near enough to the margins of each community to be able to critically reflect on the similarities of the two communities, while also maintaining enough legitimacy in both communities to be seen as “insiders” (Clavert et al., 2015). As Wenger put it, they “belong at the same time to both practices and to neither” (p. 109).

In this dissertation, the mathematics instructor and I, as former elementary teachers, are members of all the subject-area communities of practice, and the literacy instructor is a member of the literacy and social studies communities of practice. The TCs themselves are also members of all the subject-area communities of practices as novices, which positioned all of us as potential knowledge brokers between subject-area communities of practice.

Elementary Teachers and TCs as Knowledge Brokers

Revisiting the literature reviewed in the previous chapter through the lens of the boundaries of communities of practice, three studies extended Shulman's (1986) model of teacher knowledge to include an additional level of knowledge needed by elementary teachers that goes beyond the content knowledge and pedagogical content knowledge of at least four major subject areas (i.e., literacy, mathematics, science, social studies; Boche, Bartels, & Wassilak, 2021; Brand & Triplett, 2012; Heimer & Winokur, 2015). Although they each used different terms for this construct, it involves the ability to make conceptual connections across subject areas and apply pedagogical knowledge to create lessons that combine concepts from multiple disciplines. In the terms of communities of practice, elementary teachers need the ability to be knowledge brokers among the subject-area communities of practice, identifying boundary objects (i.e., conceptual connections) and creating lessons that highlight those connections. In this dissertation, I examine the types of connections TCs made between mathematics and literacy, as well as the contextual factors that made those connections possible.

CHAPTER 4: METHODOLOGY AND METHODS

Methodology

In keeping with my theoretical framework, I used an interpretivist case study methodology (Dyson & Genishi, 2005; Stake, 2005) to investigate my research questions about the types of connections that teacher candidates (TCs) make across mathematics and literacy, and the role of context in making those connections. Case study has been defined in different ways, but in most methodological traditions, the purpose of a case study is to illuminate a complex social phenomenon in a particular real-world context. There are considerable differences, however, in the epistemology underlying different approaches to case study.

One approach is typified by Yin's (2014) realist perspective. This perspective assumes “the existence of a single reality that is independent of an observer” (p. 17). In other words, there is an objective truth that case study researchers can discover. In this approach, the role of the researcher is limited to a passive observer. Although Yin acknowledges participant-observer as a potential role for the researcher, he cautions against it because of the high likelihood of introducing bias. This implies that a researcher can avoid bias if they merely observe. This same perspective can be seen in his approach to analyzing data by looking for patterns that “emerge” from the data. For Yin and other case study researchers who adopt this epistemology, the goal of their study is to unearth, or uncover, truths about the phenomenon being studied in a particular context.

In contrast, interpretivist case study researchers emphasize that knowledge is constructed and not discovered (Stake, 2005). Researchers with this epistemology are interested in learning about the meaning people make of their experiences in a particular context (Dyson & Genishi, 2005; Erickson, 1986; Stake, 2005). Researchers are not seen as objective observers, but rather

as co-constructors of knowledge, making sense of the way that other people make sense of experiences. As Stake (2005) stated, “the researcher decides what the case’s ‘own story’ is, or at least what will be included in the report.” The question of whether the case’s “own story” is objectively “true” is not a concern for interpretivist researchers the way it is for realist researchers.

Another difference among case study researchers is the way they define the case and the context. The idea of bounding the case is shared by many case study researchers, but there are different ways of doing this. Yin (2014) and Stake (2005), despite their different epistemological stances, share a similar definition of bounding a case. Both conceptualize a case as a bounded system, with some features that are part of the system, and some that are outside of the system, with some of those outside features forming the context. This perspective seems to suggest that the boundaries are intrinsic to the system, rather than constructed by the researcher. Bartlett and Vavrus (2017) reject the idea of bounding a case from the start, and instead suggest an emergent design – “an iterative and contingent tracing of relevant factors, actors, and features” (p. 39). In other words, they prefer to define the context of the case as they study it and things become relevant. Dyson and Genishi (2005) discuss placing boundaries around spaces and times during study design, but also emphasize the importance of redefining those boundaries as the research project proceeds. All of these perspectives acknowledge the importance of context but differ in how much the context interacts with the case. For example, Erickson (1986, p. 120) defined the context as the “broader social influences” on the case, while Dyson and Genishi (2005) include the shared practices within the physical setting as well as the larger context, and acknowledge that the context influences the things that people say and do in the physical setting.

In keeping with sociocultural understandings of language and knowledge, I used an interpretivist case study approach, drawing on Dyson and Genishi (2005). This approach was particularly helpful in this study as I am interested in the ways that TCs make sense of their experiences in learning to teach mathematics and literacy and the ways that the context in which they are learning encourages or constrains cross-discipline connections. In the study design, I bounded this case around the cohort of TCs with the courses and course instructors as part of the context. As I analyzed the data from the case, I expanded the bounds of the context to consider the influences of previous and current coursework outside of the two courses I observed, as well as the larger context of the structure of the teacher preparation program. In constructing the case, I attended mainly to TCs' explicit comparisons of mathematics and literacy learning and teaching, as well as similarities in the ways they talked about the two subjects.

Methods

In this case study, I investigated the following research questions:

1. What connections between subject areas, if any, do elementary TCs enrolled in concurrent literacy and mathematics methods courses identify?
2. How do the contexts in which they are learning to teach (i.e., separate subject-area methods courses, elementary classroom placements) encourage or limit the opportunities to make connections across subject areas?

Context of the Study

I conducted my study in an elementary mathematics methods course and an elementary literacy methods course that each served the same cohort of students. In their elementary teacher preparation program, TCs take a series of subject-specific methods courses, beginning in their junior year with a reading assessment course. During their senior year, TCs take separate science

and social studies methods courses in the fall and separate literacy and mathematics methods in the spring. After earning their degree, they complete a year-long student teaching internship, while taking a second methods course in each subject area. In the cohort-based sections of the senior-level methods courses, TCs enroll in the same section of all methods courses, and are placed in the same school for field work. Typically, the literacy methods course meets in the placement school and incorporates classroom observation activities into in-person classes in the morning, then the TCs complete their field hours in the afternoon. The mathematics methods course meets for three hours on a different day and TCs schedule their field hours for mathematics at a time of their choice. The TCs complete course assignments that involve individual, small group and whole group instruction during their field work time, as well as observe the mentor teacher's interactions with the children. This study took place in Spring 2021, during the COVID-19 pandemic, and methods courses and elementary schools were engaged in remote teaching. The methods courses each met synchronously once a week for about 60 to 90 minutes using Zoom, and TCs completed asynchronous work in between class sessions. For their field work, the TCs observed virtual instruction in elementary schools, or used video conferencing to observe in-person instruction, depending on which mode of instruction their placement school was using. The TCs were able to work with students individually or in small groups on the video conferencing platforms.

The instructors for these courses had experience with multiple subject areas. I include myself as an instructor/participant. I took a participant-observer stance throughout the study, but my participation evolved over time. I began primarily as an observer, occasionally asking clarifying questions or joining into a class activity with the TCs, but that role felt awkward from the start for two reasons. First, the TCs were aware that I was the instructor for other sections of

the mathematics courses, and some of them had been my students the previous year in a prerequisite reading assessment course, and second, the course instructors and TCs began soliciting my input as an experienced elementary teacher and teacher educator. As a result, I took on more of a co-instructor role during class sessions by answering questions and occasionally facilitating discussions in breakout rooms, to the point where one participant forgot why I was there and asked why I was co-teaching both courses. Because my focus was on the connections the TCs made across mathematics literacy and the contexts that supported connection-making, I decided to include myself as an instructor in the analysis of the context and considered the ways my interactions with the TCs supported or discouraged making connections.

All participants and instructors self-identified as white. The three instructors self-identified as white women, with one also self-identifying as Jewish. Eleven of the thirteen participants in this study also self-identified as white women, and two participants self-identified as white men. I have 18 years of experience teaching all subject areas as an elementary teacher, and I have taught a variety of courses in the teacher preparation program, including mathematics and literacy methods courses. During my years of elementary teaching, I created many lessons that integrated learning in two or more subject areas, and my interest in cross-curricular work has extended into my research. The mathematics methods instructor had experience teaching various elementary grades in which she taught all subjects, as well as being a literacy and mathematics coach. Although the literacy methods instructor did not have experience teaching in elementary schools, she had experience with cross-curricular integration in methods courses and had taught adults for several years. Both instructors had taught a variety of courses in the teacher preparation program. Our backgrounds in multiple subject areas may have increased the likelihood of cross-subject area connections coming up in the courses.

Participants

The participants in this study were TCs who were taking concurrent mathematics and literacy methods courses as a cohort in Spring 2021. They had taken science and social studies methods courses as a cohort the previous semester. Their instructor for the social studies methods was the literacy instructor in this study, so they had worked with her the previous semester. Of the 18 TCs in the cohort, 13 agreed to participate in the main case study, which included observations of classes and collecting coursework. All 13 TCs self-identified as white; 11 self-identified as women, two as men. All TCs were in their early twenties, with the majority being 21 years old.

At the time of the study, prospective elementary teachers in Michigan chose a subject area concentration as part of their degree in elementary education. The subject area concentrations of study participants included four in language arts, two in social studies, and one in mathematics. Seven TCs did not identify their subject area concentration. Six of the participating TCs also participated in focus group interviews. All focus group participants self-identified as white women in their early twenties. Of the six TCs, two identified their teaching major as language arts, and all six were pursuing a minor in teaching English to speakers of other languages (TESOL).

Data Collection

The data for this case study included video recordings and field note observations of Zoom classes, asynchronous course work, course documents produced by the instructors, and focus group interview video recordings and field notes. All data was stored on an encrypted external hard drive, with backup copies stored on an authenticated OneDrive account.

Zoom Class Observations

I attended and video-recorded all synchronous sessions for both courses, except for the first session of the semester. Both instructors followed a similar pattern with their use of breakout rooms. They would introduce an activity or discussion prompt, send the TCs into breakout rooms, then bring them back to the main room for a whole class debrief. They usually used the breakout rooms twice per class session, although the math instructor occasionally used them three times. There were three classes where the literacy instructor only used the breakout rooms once because she needed to end class early so the TCs could attend joint meetings for TCs enrolled in all sections of the literacy methods course.

For the two or three class sessions, I observed the entire class, choosing breakout rooms randomly to continue observations. As I got to know the TCs better, I began choosing the breakout rooms more intentionally, although my reasons for choosing a particular group varied. Generally, I chose a focus participant each class session to follow into the breakout rooms based on something they said in the previous class. For example, in the first mathematics methods class, Kayla and Daniel had a conversation comparing Number Talks with Science Talks. Because they made that connection, I joined their breakout groups in the next mathematics methods class to see if they made other connections. Similarly, after Lilly, Marissa, and Elanor had a conversation about reading mathematics word problems, I decided to join their breakout rooms over the next few sessions.

Occasionally I chose a focus participant by keeping track of who I was joining each time, trying to ensure that I was hearing from all participants. For the third literacy methods class, I realized I had not yet been in a breakout room with one of the participants, so I chose his group that day. Sometimes, my choice of group was more logistical, as I tried to avoid groups with

non-participants as much as possible. Within a single class session, if the instructor kept the same groups together for a second breakout section, I rejoined the same group. Otherwise, I used the criteria above to choose a new group to observe. Table 5 shows more detailed information about the seven focus participants who made explicit connections between subject areas, six of whom participated in focus groups.

Table 5

Focus Participants

Pseudonym	Subject area concentration	Gender (self-identified)	Race or ethnicity (self-identified)	Age	Focus group?
Kayla	Language arts	Female	White	21	Yes
Elanor	Language arts	Female	White	21	Yes
Lilly	Language arts	Female	White	21	Yes
Lindsay	Language arts	Female	White	21	Yes
Marissa	Language arts	Female	White	21	Yes
Daniel	Not specified	Male	White	21	No
Amelia	Not specified	Female	White	21	Yes

During the class sessions, I took brief notes about key events, interesting comments, and other details, focusing in on episodes that seemed relevant to my research questions (Emerson et al., 2011). I looked specifically for connections across subject areas that the TCs identified, including similarities in content or pedagogy, opportunities for integrated learning, and literacy skills that support mathematics or other content-area learning. Some connections were explicit; for example, one TC explicitly stated that a read-aloud about astronauts had math content. Other connections were more implicit, such as noting the importance of choice in math tasks and allowing children to choose books they are interested in for independent reading. I also made note when they talked about the two subjects in similar ways, but did not connection them, and when they made connections between mathematics or literacy and another subject area. Noting

these connections helped me understand how the TCs make sense of similarities in general and provided some insights into their connections between mathematics and literacy.

These jottings about key events supported my in-depth field notes made after each class session. These field notes were both descriptive (i.e., details about the setting and what happened) and reflective (i.e., my comments about the description; Bogdan & Biklen, 2007). I wrote a detailed description of what happened in the key events, using as many concrete details as possible given the virtual nature of the class sessions, and included memos on my thoughts, questions, and commentaries on the key events, as well as analytic in-process memos to explore connections between events and ideas (Emerson et al., 2011). Table # gives an overview of the data from class observations.

Table 6

Overview of Data from Class Observations

	Literacy Course	Mathematics Course
Total hours of video	12 hours	17 hours
Number of class sessions	12 class sessions	11 class sessions
Approximate length of class sessions	60 minutes	90 minutes
Total number of breakout sessions	21 breakout sessions	23 breakout sessions
Median breakout sessions per class	2 breakout sessions	2 breakout sessions
Approximate time per breakout session	10 – 20 minutes	10 – 20 minutes

Course work

As a second data source, I collected participants' course work. In the literacy course, this included three projects: (a) assessing and analyzing two children's literacy skills; (b) planning, implementing, and reflecting on a sequence of two small group reading lessons for those two children, and (c) planning, implementing, and reflecting on a writing lesson. In the mathematics course, there were three major assignments: (a) learning about the school and community of their placement school, (b) assessing a child's mathematical thinking through a problem-solving

interview, and (c) planning, implementing, and reflecting on a Number Talk (i.e., a short mental math routine; Parrish, 2010), as well as some smaller assignments for asynchronous work. These included writing a math autobiography, doing an exercise in naming their identities, evaluating and adapting a math activity they found online, and creating a math teaching vision. Both courses also had video components of the teaching project, which I downloaded from the video commenting service. Some of these videos contained images of children. so I looked at the comments first to identify any episodes of interest, then observed those segments focusing only on the TC. I did not use any data from the children except where it is reported second hand by the TC in comments on the video or their reflections.

Course Documents

In order to understand and be able to describe the context, and how it may encourage or limit cross-subject area connections, I collected course documents created by the instructors, such as syllabi, project directions, announcements, and other documents. I also saved copies of class slide presentations and other documents used and created during class sessions and asked the instructors to include me in the email lists that they send out to their classes.

Focus Group Interviews

My final data source came from video recordings, field notes, and transcripts of focus group interviews. Six of the TCs who agreed to participate in the overall case study agreed to participate in an additional focus group and were compensated for their time outside of class with a gift card (see Table 5 for participant details). These focus group interviews allowed me to “deepen an understanding of what [I] observe in the classroom and sometimes help to interpret observed activities from the participants’ perspectives” (Dyson & Genishi, 2005, p. 76). These

interviews took place outside of class time, lasted for one hour each, and were recorded for analysis.

I conducted focus group interviews rather than individual interviews in order to elicit rich information from participants on their thoughts about teaching literacy and mathematics. Focus group interviews use group interaction as part of the interview, allowing participants to explore their ideas by commenting on others' thoughts, asking questions, and sharing their experience in response to others (Kitzinger, 1995). This kind of group sense-making allowed a more in-depth exploration of TCs ideas about teaching literacy and mathematics than would be possible with individual interviews.

The focus group interviews were semi-structured and had four main parts: (a) discussing what they thought was similar or different about teaching mathematics and literacy, (b) describing their vision for their future classroom, (c) responding to prompts based on in-class comments, and (d) thinking about drawing on teaching strengths across subject areas. For part (c), I selected some comments made by participants during class sessions that I thought were similar and grouped these comments by topic. There were four sets of comments on choice and agency, reading in math, writing in math, and normalizing mistakes (see Table 7). During the focus group interviews, I displayed each set of comments on a slide while sharing my screen and asked the TCs what they thought about them. I acknowledge that my position as a course instructor, researcher, and experienced teacher influenced what TCs are willing to share with me, and I analyzed my role in the collective sense-making of the focus groups in Chapter 6.

Table 7*Quote Sets Used as Prompts in Focus Group Interviews*

Topic	Quote from Literacy	Quote from Mathematics
Set 1 – Choice and agency	“Using what your students’ interests are to get them interested in reading about certain topics and even branching off of those topics into other ones.”	“I talked about agency being one of the biggest factors, so if kids have choice, they’re more likely to related it to play versus a lack of choice is more related to work.”
Set 2 – Reading in Math	“Children who are having trouble with reading, it impacts a lot of their other subjects, too.” “Our class was reading a book about astronauts and there was something about math in it.”	“I wonder if [the interviewer is reading the math problems] because [the student] is not yet reading or if it would be more of a hindrance to stop and read the whole problem and decode.”
Set 3 – Writing and Vocabulary in Math	“Incorporating writing not just into writing time, but all subjects”	“I like the integration of doing math with writing [a math autobiography].” “Teaching them the academic math language – once they learn how to read it, it’ll make the solving of real math easier.”
Set 4 – Normalizing Mistakes	“Not knowing is okay, and working to figure it out is normal”	I think [Number Talks] take the stigma out of doing math and making mistakes.

Data Analysis***Transcription***

I include transcription as part of data analysis because the decisions involved in creating a transcript are an interpretation of the interaction (Ochs, 1979). How I choose to transcribe also has implications for later analysis. Using transcription conventions for speech patterns, such as intonation, pauses, elongated vowels, stress, and pace emphasizes *how* things were said, which may give clues to things that are being left unsaid (Juzwik & Ives, 2010). A “cleaned-up” version of the language, which omits hesitations, repetitions, “ums”, “likes”, and other verbalizations,

and well as the markers for speech patterns, on the other hand, helps to focus attention on *what* was being said (Gee, 2014). Both styles of transcripts bring certain things to light and conceal other things, which makes them both useful for different types of questions. The first style is good for answering questions about how things were said and what assumptions and unstated background knowledge are implied by the speech patterns. The second style is more helpful for looking at the data for larger units of meaning.

In this study, I used transcription selectively rather than transcribing all the data. I created full transcripts for both focus group interviews to analyze them closely, as well as selected key events from the class session video recordings. I chose to use a “cleaned-up” version of the language to focus attention on the content of what was being said (Gee, 2014).

Coding and memoing

Initial analysis of the data happened as it was being collected. I wrote detailed fieldnotes, read student coursework, and did initial coding on the videos shortly after each session in MaxQDA. First, I tagged moments in the videos when the TCs or instructors explicitly made a connection between subject areas. Then, I used an open coding approach (Emerson et al., 2011), going through the tagged moments and coding them with descriptions of the connections (see table 8 for a coding sample). I drew on some of analytic methods of grounded theory in this initial coding. In particular, the stance that Charmaz (2014) takes on putting aside preconceived theories or ideas to build analytic insights based on the data was helpful in this analysis. During this initial coding phase, I used memoing to make sense of the data (Charmaz, 2014; Emerson et al., 2011) by describing what I saw as connections between subject areas. This helped me fill out my codes and suggested areas for further investigation in focus groups.

Table 8*Examples of Initial Codes*

Code	Frequency
Explicit connection by TCs	17
Explicit connection between mathematics and literacy	6
Explicit connection by instructor	34
Similarity, but not explicitly connected	22
Children's literature in math ^a	2
Reading in math ^a	6
Fluency ^a	2
Early literacy and early numeracy ^a	1
Basics not defining subject ^a	7
Immersed in text/numbers ^a	1
Productive struggle ^a	3
Play vs. work ^a	9
Assessment ^a	20
Powerful and meaningful teaching ^a	3
Small group instruction ^a	9
Connections to other subject areas ^a	10

^a Frequencies for these codes include connections by TCs and by instructors.

To answer my first research question on what connections between subjects TCs make, I developed a conceptual framework of types of connections by revisiting the scholarly literature on connections between mathematics and literacy. Working iteratively with my data and the literature, I used the most significant or most frequent codes to construct larger categories that summarized or synthesized the themes in the data and literature. Using the constant comparison method (Charmaz, 2014; Glaser & Strauss, 1967), I compared the newly coded data with previously coded data to identify larger categories; namely, integrated learning, language as a basis for learning, and similarities in teaching and learning (see Chapter 2 for a detailed explanation). Using this framework, I revisited the data to begin more focused coding on the class session videos, focus group transcripts, and coursework, coding each instance of connections as one or more type.

My second research question asked how the context(s) in which the TCs were learning to teach encouraged or limited opportunities to make connections across subject areas. To answer this question, I revisited the moments in the class sessions where TCs had made explicit connections, and created transcripts for those five episodes, as well as four other episodes where they made connections between mathematics or literacy and another subject. I coded those transcripts and the focus group transcripts for the events that appeared to prompt connections. This was an iterative process: as I noticed new aspects of the contexts that encouraged connection-making, I revisited the other transcripts to look for evidence of that aspect. For example, after I noticed Kayla acting as a knowledge broker by connecting mathematics word problems to reading comprehension, I read through the transcripts again, coding moments where the TCs or I acted as knowledge brokers. Finally, I looked for patterns across the events that prompted connections, the knowledge brokering, and the types and depth of connections that were made.

CHAPTER 5: TYPES OF CONNECTIONS

This chapter examines the types of connections made by teacher candidates (TCs) taking concurrent mathematics methods and literacy methods courses. I classified the connections participants made in their coursework, in-class discussions, and during the focus group interviews, using the conceptual framework described in Chapter Two. To summarize, the framework was developed using an iterative process with the initial coding of data and review of literature connecting literacy and mathematics learning and teaching. I developed three categories to describe the types of connections – curriculum integration, language as a basis for learning, and similarities in learning and teaching. Curriculum integration includes any sort of curriculum creation or lesson planning that uses more than one content area to learn a particular topic (e.g., interdisciplinary learning, project-based learning, thematic units, etc.) or that combines learning objectives from more than one subject area in a single lesson. A second category of connections are grounded in the idea that language is the basis of all learning. With literacy and mathematics, this means using literacy skills (i.e., reading, writing, listening, speaking) to learn mathematics. A common example in literature is students learning to read and write mathematical texts. The third category is about similarities in learning and teaching, and includes three sub-categories: learning goals, thinking skills, and pedagogy. These include things such as content and practices standards, thinking strategies such as metacognition, and instructional strategies. Although I treat these as separate categories, there is a lot of overlap between learning goals, thinking skills, and pedagogy as they tend to interact with one another, and TCs' comments were frequently coded with more than one of these sub-categories.

Overview of Findings

Nearly all of the connections that the TCs in this study made were about language as a basis for learning and similarities in teaching and learning, with more in similarities. Curriculum integration was only mentioned four times, in relation to two specific course assignments. Table 9 shows the number of coded segments for each major category and selected sub-categories.

Table 9

Number of Coded Segments in Each Category

Category	Number of coded segments ^a
Curriculum Integration	4 (5%)
Language as Basis for learning	33 (39%)
Reading	9
Writing	13
Vocabulary	6
Speaking/Listening	3
Children's Literature	2
Similarities in Teaching and Learning	48 (56%)
In Learning Goals	8
In Thinking Skills	6
In Pedagogy ^b	34
Choice	7
Connect to lived experience	10
Mistakes as learning/productive struggle	6
Process vs product	4
Total	85 (100%)

^a totals may not match due to segments with multiple codes. ^b only subtopics in pedagogy with four or more segments are listed.

The following sections will look closely at the nature of the connections mentioned by the TCs, beginning with curriculum integration, then language as a basis for learning, and concluding with similarities and differences. Finally, I will discuss implications for teacher education.

Curriculum Integration

Curriculum integration was the least mentioned category of connections for these TCs and was always related to coursework. There was a total of four coded segments, two of which were part of the same in-class activity, and the other two were reporting on an assignment from a different course. The in-class activity took place in the literacy methods course. The instructor, who had taught their social studies methods course the previous semester, shared the children's book *Bowwow Powwow* (2018) by Brenda J. Child, Red Lake Ojibwe, and asked the TCs to work in groups in breakout rooms to create a lesson that included both literacy and social studies standards. I observed Daniel, Marissa, and Elanor as they worked to create this lesson. Figure 3 shows an excerpt of the lesson plan, showing the standards they chose and the learning target they created.

Figure 3

Standards and Objectives for Integrated Social Studies and Literacy Lesson

Overall lesson topic/title: Illustration connections

Learning Target/Objective for this lesson: Students will be able to draw connections between informational texts about the Ojibwe people and illustrations within *Bowwow Powwow*.

GLCE: 3 – H3.0.4 Draw upon traditional stories and/or teachings of Indigenous Peoples who lived and continue to live in Michigan in order to better understand their beliefs and histories.

CCSS: CCSS.ELA-LITERACY.RL.3.7

Explain how specific aspects of a text's illustrations contribute to what is conveyed by the words in a story (e.g., create mood, emphasize aspects of a character or setting)

Rationale: Students will be able to better understand a indigenous group's culture through comparison and understanding of text and images.

Similar to the TCs in Heimer and Winokur's (2015) study, the connection created in this lesson seems to be surface-level, with using the illustrations in *Bowwow Powwow* (Child, 2018) to compare to other nonfiction texts about the Ojibwe people, rather than delving into how the

illustrations contribute to what is being conveyed in the story and in the nonfiction text. With more time, they may have developed a deeper connection between the two subject areas, but they were limited to 20 minutes of in-class time.

Elanor and Daniel both shared out in the whole class follow-up discussion about the difficulty of choosing standards, but Daniel also noted that literacy and social studies pair well together to use reading and writing to understand cultures. Kayla thought integrating subject areas might be easier if they had a predetermined grade level to plan for, as this would narrow the number of standards they were looking at.

The second discussion of curriculum integration occurred in the two focus group discussions. Lilly and Elanor both shared lessons they created for an English as a Second Language (ESL) methods course they were taking. They were asked to create a lesson for emerging bilingual students that incorporated language standards (World-Class Instructional Design and Assessment (WIDA), 2014) into any content area. Lilly created a lesson on solving word problems that incorporated support for children who speak Spanish, and Elanor's lesson on ordering three objects based on length provided vocabulary support with pictures of the objects labeled with the English words. Although these lessons are focused more on using language, specifically English, for learning, both TCs expressed their enthusiasm for the idea of meeting standards from more than one subject area in the same lesson, even though they felt intimidated by the project at first. It was not surprising that this type of connection occurred so infrequently because curriculum integration rarely came up as a topic in the two methods courses.

Language as a Basis for Learning

Reading, writing, speaking, and listening are skills that are used across the curriculum to learn. As Elanor said, "Reading is involved in every subject area, same with speaking, just all of

the language skills are involved in all subjects.” When the TCs spoke about language as the basis for all learning, they tended to talk about the role of receptive language skills (i.e., reading and listening) separately from productive language (i.e., writing and speaking), with vocabulary included with receptive language.

Reading, Listening, and Vocabulary

A common theme across TCs comments about the role of reading in mathematics was expressed by Kayla and Lilly in nearly identical words at different points in the semester: If children are having trouble reading, it impacts a lot of other subjects, too. TCs across the class sessions and focus groups mentioned some ways that reading can negatively impact mathematics learning when children have difficulty reading word problems. For example, in reflecting on a problem-solving interview that she conducted with a child, and other interviews by her peers that she observed, Elanor noticed that getting stuck on decoding “was affecting [the children’s] confidence level going into solving a math problem “ and that “the reading really impacted how they did the math because if they weren’t sure if they were supposed to find a sum or a product or whatever, then that really went into how they went about solving the problem.” Elanor emphasized the impact both on students’ confidence levels and the accuracy of their answers. Earlier in the semester, while talking about a video of a problem-solving interview, Lilly and Elanor noted that listening comprehension plays a similar role in mathematics that reading does - students need to comprehend the questions being asked in order to answer them.

Elanor: For the last [question], she [the child] asked to have it read back three times. It’s just a little bit more confusing, I think. So, like, kids might have the inclination to just add the first two numbers they hear, or whatever. So, when they say 8 cookies and 6

cookies - it's easy to just think of it as "Oh, $8+6$ is 14" but she took the time to keep asking until she felt comfortable knowing what it was she was supposed to find.

Lilly: I was surprised that [the teacher in the videos] didn't provide any written questions.

I know that she made them on the fly with the dandelion thing, but even as an adult, I would probably ask them to repeat that, because some of those were lengthy questions.

The examples that Lilly and Elanor used illustrate how important it is for students to comprehend word problems, whether they are presented verbally or in written form, but at this point, they had not yet begun to consider how they might support children in reading mathematics texts, other than generally helping them improve their reading skills.

This began to change when thinking about reading comprehension in the context of mathematics word problems led to the idea that word problems are a unique genre of text. "It's definitely a particular type of type of writing, the way that they're written. It's not like reading an informational text or a story. It's its own sort of thing, that students have to be familiar with the structure." Elanor's comment illustrates the change that began to happen in the focus group discussions once the TCs started thinking about word problems as a genre of writing. They started applying what they had learned about components of reading from an earlier course to word problems. The course, which the TCs took the previous year, used the cognitive model of reading (McKenna & Stahl, 2003). In this model, reading comprehension is composed of three sets of interrelated skills – automatic word recognition (i.e., phonological awareness, print concepts, decoding, sight words and fluency in context), language comprehension (i.e., vocabulary, background knowledge, and sentence and text structure) and strategic knowledge (i.e., purposes for reading, knowledge of reading strategies.)

In Elanor's comment above, she concluded that, since understanding text structure is one of the components of reading comprehension, and word problems are a particular genre of writing, students need to learn about the structure of word problems. Other types of connections between reading mathematics text and the cognitive model of reading continued to come up in the focus group interviews.

Kayla: [talking about reading books] They would always read it really well, but then the comprehension part - there was a quiz at the end, and they would sometimes forget all the information. I think that it does have an effect on everything, like reading comprehension, if it's for science and you're reading your science book, or even math. Usually when you look at math problems, there's words as the directions too, so they might not understand the full concept of what it's asking.

Elanor: And, if you're devoting all of your time when you're reading to decoding rather than comprehending... Like you said, they might read it pretty okay, but their attention is directed at getting the sounds right and not at 'what am I actually reading?' So if your attention is divided on anything else and that impacts your comprehension.

In this excerpt, Elanor and Kayla are referring to research on reading and the limits on working memory. If too many mental resources need to go to decoding, there is little left for making sense of the text (Rueda, 2010). This is often named as the reason children need to work towards automatic word recognition, especially as the texts they read become more complex. Elanor and Kayla were beginning to think about why troubles with decoding were affecting children's understanding of word problems.

Another connection the TCs made between reading mathematics problems and the cognitive model of reading is the importance of vocabulary in reading comprehension. Kayla

pointed out that vocabulary is an important component of comprehension, “Understand[ing] what the story problem is trying to say and what the question is, that’s an important comprehension skill as well as the vocabulary that’s present.” Several TCs noted the uniqueness of some mathematics vocabulary, and that knowing that vocabulary is important to students’ understanding. Lilly mentioned that “teaching them the academic math language – once they know it, it’ll make the solving of math easier,” and Elanor added that there are content vocabulary words in word problems that are not found in other kinds of texts. Marissa gave an example from her own experience. “On our [teacher certification] exam, they had questions like, ‘Find the adjacent angle’ and if a student doesn’t know [what an adjacent angle is], they’re going to miss a problem on a test.” These observations are consistent with research on the mathematics register and how these discipline-specific words and meanings can be confusing for students (Colwell & Enderson, 2016; Fogelberg et al., 2008; Lemley et al., 2019; Schleppegrell, 2007).

In addition to the uniqueness of mathematics vocabulary, Amelia added an interesting observation to the conversation about the role of vocabulary and background knowledge in the accessibility of mathematics. She said:

I feel like a lot of word problems and stuff that happens in math are very centered on the typical experience that white students have. I’ve been in classrooms before where students have just not understood part of a word problem. I’ve presented word problems to students and they’re like, ‘I don’t know what that thing is. What is that?’

Knowing the role of students’ vocabulary and background knowledge in reading comprehension, Amelia made the great point that mathematics content that is centered on typical white experiences creates additional barriers to mathematics for students who have different life

experiences, in addition to the difficulties they may have with vocabulary traditionally associated with the mathematics register.

Writing and Speaking

A second theme in the use of language in mathematics learning is the role of expressive language (i.e., writing and speaking). The TCs spoke about their own experiences using writing or speaking to make sense of mathematics, as well as how they might use writing and speaking with their own students. They used several metaphors for the role of writing in sense-making, including writing as self-reflection, writing as remembering, and writing as finding connections.

One of the first assignments the TCs completed for the mathematics methods course was a math autobiography, describing their own past experiences with mathematics, and this assignment was referred to frequently in the talk of using writing in mathematics. Lindsay, Elanor, and Kayla talked about the ways that they used the math autobiography to reflect on their own experiences with learning mathematics and how that might impact the way they teach. Lindsay shared “I liked [the math autobiography] a lot because I haven't really reflected on my math experiences in a long time, so it just made me realize what I like about math, what I don't like about math.” Kayla and Elanor also talked about the possibility of writing to help their students self-reflect on what they have learned.

Kayla: I also like the concept of maybe like a self-reflection thing across all subjects, using writing as kind of like, ‘We learned about this in math class and I show room for improvement in this,’ or ‘this was something that I didn't really understand,’ and having kids self-reflect on what they're actually learning in all the different subjects. I actually had a math journal in middle school, and every time we did problems in class, you'd have to write down what did you learn. I hated it at first, but once I started doing it, I was able

to look back and say, Wow, that's actually connected with this thing that we're going to do next, so I think that'd be really cool, just being able to actually reflect on it.

Kayla described how writing had helped her to see connections between mathematics topics that she may not have noticed otherwise. In addition to self-reflection, Kayla and Elanor discussed using mathematics to remember and consolidate learning. Kayla described children explaining their thinking as an act of teaching, which can help them learn that material. Elanor expanded on Kayla's idea:

That reminded me, what you said before - like, a good way to demonstrate your understanding is to try and teach it to somebody else. So whether that's through written instructions or spoken instructions, both of those are literacy skills and you can demonstrate your understanding of something in a different subject area by explaining it to other people and trying to teach that way.

Kayla and Elanor characterized explaining a topic to someone as one way of sense-making and demonstrating understanding, and clarified that explaining can happen verbally or in writing, both of which are expressive language skills. Journal-writing, as well as other genres of writing, is recommended by many mathematics education scholars as a way to explore and make sense of ideas (e.g., Armstrong et al., 2018; Burns, 2004; Douville et al., 2010; Thompson & Chappell, 2007).

Using Children's Books in Mathematics Instruction

Although there is a lot written about the use of children's books as a context for mathematics, this was not a connection that occurred to most of the TCs in this study, with only two mentions across the semester. Early in the semester, while sharing what mathematics they had seen in their placement classrooms, Lindsay commented on how a child in her placement

class noticed some mathematics in an interactive read-aloud about astronauts and how her mentor teacher confirmed that the mathematics in the story was something they had been working on earlier that week in math class. The second mention of mathematics in children's books happened during a focus group discussion about making mathematics relevant to students. Kayla mentioned having seen children's books with math problems or features like timelines that could be used to make mathematics more real and relevant. This is consistent with Prendergast and colleagues' (2019) finding that, despite the benefits of using children's literature in mathematics class, 90% of the teachers in their study never or infrequently used books in mathematics instruction.

Similarities (and Differences) in Teaching and Learning

A little over half of the connections made by the TCs in this study were about the similarities and differences in teaching and learning mathematics and literacy. Although differences are not typically associated with connections, they are a way of making logical links between two ideas (Merriam-Webster, n.d.) and I included them here as a sort of connection because they illuminate some of the ways the TCs think about mathematics and literacy.

Differences in Teaching and Learning

The most common theme about content was that mathematics and literacy are foundational skills, although they gave fewer examples of the ways mathematics was foundational. Several TCs made comments about the need for literacy and mathematics in daily life, such as reading signs and text messages and doing taxes. Marissa thought it might be easier for children to see examples of needing literacy than needing mathematics in daily life:

Math, it's like memorizing equations and why do I need to know this? How is this going to affect me later in life? Whereas literacy, it's like you need it to get by in day-to-day

tasks, you can't read road signs or you can't read text messages. At least in the US nowadays, it's really hard to be illiterate. You can't get by as well as you can if you're like, I'm just really bad at math.

Marissa was thinking of mathematics as memorizing equations and that people do not use equations on a regular basis in day-to-day life; her conception of what mathematics is appears to be narrower than her conception of literacy. Lilly also appears to have a similar conception of mathematics as memorizing in this excerpt where she talks about how mathematics and literacy are different:

Math is more heavily viewed as a memorization area of learning for students, and that's why it can be intimidating, especially for students who aren't necessarily comfortable memorizing or don't have that style of learning developed as much as other students do. So I think that that's one big difference is that math feels like more memorization, but really in the same way that students recognize numbers, they are recognizing letters and words and sounds, so there is more similarity in the subjects, but it's more like the way that they're stigmatized which is interesting.

As she was stating that this was a difference that she saw between mathematics and literacy, she seemed to change her mind when it occurred to her that students do memorize some things in literacy, which made her wonder why mathematics carries the stigma of being only about memorizing but literacy does not.

The TCs also noted that literacy and mathematics are both needed for other subjects in school, although, again, most of the examples they gave were for literacy skills used to read and write about mathematics, science, and social studies. Those examples were included in the section above about language as a basis for learning. Elanor did have one example of the use of

mathematics in reading, describing how the first graders she was working with had trouble reading page numbers:

The kids have a very hard time getting to page numbers in whatever book they're using, [like 397]... these are first graders, and they're just learning about the tens place and the ones place right now.... It makes sense that they don't understand yet that going from this direction [in the book] means the numbers are going to get higher... The numbers are everywhere and in everything, and I feel like you can tie that in into a discussion on place value.

Although this is an example of using a mathematics concept (i.e., place value) in a literacy context, it is more focused on a functional issue rather than any literacy concepts. In the earlier section on curriculum integration, the TCs mentioned how they found creating integrated lessons difficult or intimidating. Spending some time on comparing content standards across subject areas in a similar way to some of the research articles on shared content and practices (e.g., Cheuk, 2012; Wohlhuter & Quintero, 2003; Yilmaz & Topal, 2014) might be beneficial for these TCs in thinking about the overlaps in mathematics and literacy learning.

Sense-Making as a Similarity

The TCs had more to say about the similarities in thinking skills involved in learning both subjects. Elanor noted that, in all the subject-area methods, her instructors were emphasizing sense-making:

We were talking about sense-making today with math and then reading comprehension is such a big thing, that's also constructing meaning. And we talk about that a ton. That's also something we talked about in science, the fact that, really, what students are doing

when they're learning new things is just making sense of phenomena that exists, and so yeah, that definitely applies across all subjects.

Elanor also mentioned in a class earlier in the semester about different practice she was learning across all four content methods courses that she called “powerful and meaningful teaching” which were all focused on conceptual understanding of content.

Focusing on the Process, not Just the Final Product

Connected to the idea of sense-making in all subjects, several TCs asserted that learning should be a process that supports sense-making. During their focus group discussion, Amelia, Lindsay, and Marissa argued that literacy learning was already a process, especially writing, and that mathematics should be more like that.

Marissa: I think the idea of literacy and writing being a recursive process should be transferred over to math as well. I think the way that it's traditionally structured for math education is that you need a building block before adding another; before adding another. Whereas literacy, there's more of a fluid, versatile understanding of like, ‘You may not know how to write this yet, but we're going to work on that.’ ... I think allowing more fluidness in math [would be helpful.]

Amelia: I feel like in literacy, we practice so much. There's so much practicing how to write, and we write so many rough drafts and we do outlines and so many steps before you get to the final version of what you're producing.

Lindsay: And getting rid of ... the stigma around being right. It's okay to make mistakes. It's okay if you don't understand something we just learned two days ago. just going off what Amelia said, you want to be able to allow them to have practice.

In this conversation, Lindsay, Marissa, and Amelia are talking about the difference between focusing on the product of learning versus the process of learning. In literacy, there is a final product, but it is not the only thing that is important. The process of revising your writing is just as valuable as the end product. They argue that mathematics should be the same. Elanor and Kayla made a similar argument and connected it to what they were learning in the mathematics methods course:

Kayla: I think normalizing making mistakes and normalizing the process of figuring something out is great...I think that goes a lot with the number talks. There's a perfect amount of wait time for every student, and you can explain your answer as well, it's not just the first answer. Everyone kind of has a chance, and I think that also goes for reading, you don't want to tell kids what the actual word is, you want them to use the different processes of figuring out how to pronounce it, what it means, using the context clues.

Elanor: I think prioritizing the process over the product is really important, and that helps kids who maybe wouldn't be willing to share because they're worried about having the wrong answer ... One thing that I think of is writing, where ... there's eventually a final product, but it's really about the process. That's something that we were talking about in math today, is that it's a process and it's okay to not be correct, which is something we learn a lot in literacy ... So if we sort of approach math in that way, I think that can ... make it seem more like a process where it's okay to trip up and go back and edit and learn from that.

In her focus group, Marissa pointed out that it's important to build a culture in the classroom where making mistakes is okay, and create "a shared vulnerability, so students feel comfortable

not only making mistakes, but *allowing their peers to make mistakes* [emphasis added].” She went on to talk about how this can be difficult, especially with older students who may not have experienced this kind of approach to mathematics learning, or in communities where traditional mathematics has been the norm, where getting correct answers is prioritized.

Multiple Perspectives or Solution Strategies as Valued Parts of Learning

In addition to discussing the importance of mistakes in learning, Kayla and Elanor talked about valuing different points of view in both literacy and mathematics.

Kayla: I think because I was the one that drew 24 cupcakes for a division problem instead of using long division, I think I have almost a different lens on math where I would like to see all your very weird processes for how you got to the answer. I think that's important. Same with reading, you're predicting what's going to happen, you're making inferences about a book. Everyone thinks of a book they're reading in a different way. ... I think that's similar to math, everyone looks at a problem differently. ... It's a positive thing that kids have different ways to solve problems.

Elanor: I really like that. I mean, even that sort of made me feel more comfortable [about math], like right now... You drew the 24 cupcakes, and you want to see the kids that are going to do the 24 cupcakes, or the kids who are going to use the standard algorithm and that kind of thing. ... We all do things in a different way. I love having discussions with people on novels and what did you interpret the ending to be when there's ambiguous situations. ... Taking that sort of perspective in math, I think that that's something that I then feel more comfortable with because it's something that I like to do with books. ... so it's like, ‘Why can't we take that sort of vision when it comes to math?’ and I think we can.

Thinking about Kayla's experience of being the one with the 'weird' ways of solving math problems, and how Kayla liked hearing about other people's ways of solving, Elanor noticed that it was similar to the way that she felt about hearing other people's perspectives on books, movies, music, and more. As she asked, "Why can't we do that with math?" Treating math discussions more like the kinds of conversations that happen around interpreting books and other creative works could lead to thinking about different ways of solving problems as valued, and even essential, parts of learning mathematics.

The Role of Choice and Fun in Motivation

The TCs noticed many similarities and differences in pedagogy, including things like types and roles of assessment, the ways that small group instruction is used, and how learning activities are perceived as play or work, but most of their comments focused on two themes: the role of choice and fun in children's motivation to learn, and the importance of connecting learning to children's lived experiences.

There were two mentions of the role of choice and agency in student motivation during class sessions that were not connected by the TCs at the time. In their mathematics methods course, Marissa was sharing out after some small group discussion about play in mathematics, "I just talked about agency being one of the biggest factors, so if kids have choice, they're more likely to relate it to play versus a lack of choice is more related to work." The other mention of choice was during a literacy methods class discussing a reading assignment on vocabulary instruction. Daniel pointed out the importance of agency in word choices: "I like how they [the authors of the assigned reading] talked about giving your students agency. Like if they find a word in a book they're reading, and they can bring that to class and ... teach others that word that they learned." I asked the TCs who participated in the focus groups to say a bit more about

what they were thinking about the role of choice and agency in mathematics and literacy learning. Marissa, Amelia, and Elanor all made separate comments about the benefits of choice on students' learning.

Elanor: Children having choice and having independence ... that tends to make kids excited because they get to choose things that are relevant to them or interesting to them.

Marissa: I think agency is one of the most important factors of learning in general, students benefit when they feel in control, everyone wants to be in control of their own destiny and learning. I feel like traditional schooling methods that you have to go to your class at a specific time and then do all the work that we're assigning you, it makes people feel powerless ... I think transitioning it to students have more agency, students can see the value in what they're learning and how it will impact their lives later on can be really beneficial.

Amelia: If you're a teacher and you want your students at school to be engaged in what they're doing and produce the best work that they can produce, give them something that they want to produce work about, like make it a passion project for them.

All three of these TCs recognized the relationship between choice/agency and motivation to learn. The examples they gave of what it might look like for children to have choice in schools came from both mathematics and literacy. Some of the things they mentioned included choosing materials for a math exploration or a topic to write about, choosing who you want to work with, choosing a way to solve a math problem and choosing things to read that they are interested in. Amelia pointed out that "when it comes to literacy and stuff, there's no harm in letting students choose things that they are interested in to read or write about, it just doesn't even seem like it should be a debate." When she made this comment, she seemed to imply that it is obvious that

students should choose books and writing topics, but maybe not so obvious to others that students should also make choices in mathematics.

In addition to talking about how choice can be motivating to many learners, they also talked about the role of play in motivation and learning for children. In the quote from mathematics methods class above, Marissa had mentioned how choice can make an activity feel more like play than work, and Daniel added that if it feels like work, it is less fun.

If they start thinking that's its work, then they're going to disengage, but as long as they're doing it on their own, they're not going to mind it. But, as soon as there's too much structure or too clear of an objective, the more it feels like work, and they're not going to want to have fun with it anymore, really.

This idea of fun came up multiple times in the focus group discussions. Marissa talked about connecting learning to free play by “allowing them to play with different things and then incorporating math vocabulary or different types of math games in free play activities, like Monopoly or Life or any board game has math in it.” Lilly agreed that “there are so many math games that you can play,” and Amelia noted that “using manipulatives can feel like productive math play.” Kayla described her future classroom as a place where “I want our language arts and math, I want it to be exciting, I really want it to be fun. I want them to be able to use movement in the classroom and get up from their seats.”

Connecting Learning to Students' Lives

The second theme about pedagogy continued with the importance of engaging students in learning with a focus on connecting learning to students' lived experiences. For example, Marissa shared, “we just need to get away from the idea of input, output method with math learning and focus more on what are the practical applications of this in real life.” The TC's

focus on connecting learning to lived experience went beyond just a general “real life” to be specific about connecting to the lives of their particular students and questioning whose “real life” we are connecting to. Elanor suggested connecting mathematics with children’s lives outside of school by “being creative with your math assignments and making them sort of practical, connected to life, ... [for fractions] maybe bring a recipe that your family likes to make.” Marissa made a similar comment about how it was important to “use students’ funds of knowledge when constructing lessons,” and Lindsay talked about the value of being culturally aware and allowing students to be themselves. Amelia talked specifically about the importance of countering the way mathematics curricula center white experiences by “finding artifacts and different parts for a math lesson that can reach a wide array of students in your classroom, culturally and socially, things that relate to their family and their lives outside of school,” and Lilly talked about using a translinguaging stance to support emergent bilinguals and incorporating language learning into all content areas. These ideas are similar to the teachers in Matthews and Rainer’s (2001) study about engaging with students’ experiences, with these TCs specifying that we need to question whose experience is being centered in math classes, and how to make mathematics culturally relevant, something that Amelia thought was not emphasized enough in mathematics methods compared to literacy methods.

In describing her future classroom, Marissa drew on Bishop’s (1990) metaphor of books as mirrors reflecting children’s lives, windows that let them see into others’ lives, and sliding glass doors that invite them to join. She said:

[I want to introduce] books that the students may not really have grown up with necessarily, or providing them experiences with lives that they don't or haven't lived,

like... What's the metaphor? It's like 'Books are mirrors. Books are windows.' Yeah, so windows into other circumstances, like life circumstances for students.

Kayla drew on the same metaphor when she said, "I think the things we've been learning in math, especially just making sure that students can see themselves in the problems too, and they're applicable to their lives, it's just like the reading." The TCs in this study were focused on the idea of making all learning culturally relevant and accessible to students in ways that were not common in the research literature about connections across subject areas.

Implications for Elementary Teacher Preparation

The TCs in this study made a variety of connections between mathematics teaching and literacy teaching. The next chapter will more deeply explore the question of what circumstances encourage or inhibit making connection across subject areas, so this discussion will focus on the implications of the types of connections the TCs made.

Curriculum Integration: Comparing Content Across Subject Areas

The TCs in this study only talked about integrating curriculum in response to assigned course activities. This is similar to previous findings about how practicing teachers and TCs think about the similarities and differences between the content of different subject areas. For example, in DeLuca, Ogden, and Pero's (2015) study of TCs experiences in an integrated subject area methods course, the TCs reported that the course 'forced' them to think about what was common across the subject areas, implying that they would not have thought about it in separate subject area methods courses. The findings in this dissertation as well as research literature also suggest that teachers need time to think about and reflect on similarities in content. For example, the teachers in Matthews and Rainer's (2001) made surface-level connections between mathematics and literacy at the beginning of their inquiry, but began to notice deeper

connections the more they reflected on common content. Heimer and Winkour (2015) found that TCs creating integrated learning units tended to focus on surface-level connections between subject areas, which is similar to the TCs in this study. It could be argued that TCs are just beginning to think about similarities and differences in content and, with more time and opportunities to compare across subject areas, could learn to make those deeper connections.

Learning to use children's literature in mathematics may also require a deeper understanding of commonalities across subject areas. Although there is much research on the benefits of children's literature on math learning, including the way books tend to increase children's motivation to engage with mathematics, not much time was devoted to this topic during these methods courses beyond a few fleeting references. Even practicing teachers, who would be more familiar with content learning standards than TCs, do not make frequent use of children's books in mathematics (Prendergast et al., 2019). Considering the emphasis on the importance of children's motivation to learn by TCs in this study and by practicing teachers (Matthews & Rainer, 2001), using children's literature in mathematics seems to be a way to increase motivation. This disconnect suggests that there is something preventing TCs and teachers from thinking about how to use children's literature in mathematics, and it could be a need for deeper understanding of the similarities between literacy and mathematics learning goals, which would require time devoted to comparing standards across subject areas.

Reading and Creating Mathematical Texts: Disciplinary Literacy

Another implication is the need to think about disciplinary literacy (i.e., reading and creating mathematical texts) both in connection to research on how children learn to decode and comprehend text, as well as thinking of mathematical text more broadly. At first, the TCs were only thinking of the ways that reading comprehension and decoding create a barrier to

demonstrating understanding of mathematics. As both an elementary teacher and as a teacher educator, I often experienced this dilemma of acknowledging the ways that reading skills impact students' mathematics learning without thinking about what should be done about it beyond generally improving children's reading skills. Once the TCs began thinking of word problems as a genre of writing, they began to draw on what they had learned about teaching reading to think about how to support children in reading and understanding mathematics word problems. They went beyond the need to decode the words to think about the role of vocabulary, background knowledge, and text structure in reading comprehension and how they might support students in gaining the knowledge they need to make sense of word problems. An important implication for teacher preparation is that we need to attend to disciplinary literacy in mathematics and connect it explicitly to research on learning to read. In addition, it is important to think about the reading demands of other types of mathematics texts. Although the TCs in this study did start to apply what they knew about decoding and comprehending text to word problems, Draper (2002) called for a broader definition of mathematical text, including graphs, equations, drawings, and other non-text-based ways of conveying information. Expanding this definition to include visual displays of information can be connected to literacy learning goals of "interpreting information presented visually... or quantitatively" (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010b, CCSS.ELA.Literacy.RI.4.7), but would require TCs to learn about how children learn to interpret visual and quantitative information. In order to support TCs in making these connections, mathematics teacher educators would need to know something about teaching reading and how children learn to read.

Decompartmentalizing Elementary Teaching

The connections the TCs seemed to find most powerful, especially for those who felt some anxiety towards teaching mathematics, were those that helped them reframe what mathematics teaching and learning could look like. Early in the semester, Elanor asked her literacy instruction, “We’ve been learning about these meaningful and powerful ways to teach – powerful social studies, number talks, science talks, no more look up the word vocabulary instruction - but my question is, how do we find the *time* to do them all?” Elanor recognized that the instructional strategies she was learning were focused on conceptual understanding and not memorization, but her question about how to find the time suggests that she was thinking of the goals of each of those strategies as separate, and she likely was not the only one. By the end of the semester, the TCs who participated in the focus group were beginning to think about the similarities among these practices, including a focus on the process of learning instead of only the product. Elanor and Kayla, in particular, were thinking more about the similarities between some of these practices in their conversation about valuing multiple perspectives in both mathematics and literacy. As Kayla shared her experience of being the one with the ‘weird’ solution strategies as a student, and how that makes her want to hear everyone’s way of solving mathematics problems, Elanor realized that is exactly what she loves to do in discussing literature. By drawing on a strength of hers in this way, she was beginning to feel more confident about her ability to teach mathematics. This type of thinking only took place in the focus groups, suggesting that TCs may need time that is specifically dedicated to thinking across subject areas, as well as the support of an instructor who is also thinking holistically about elementary education. Again, this points towards the need for elementary mathematics teacher educators to be familiar with more subject areas than just mathematics.

Implications for Research

One implication for research is the need to attend to issues that are important to teachers. In this case, the types of connection that the TCs seemed most interested in were connecting learning to children's interests and lives in ways that increase their motivation to learn. This includes thinking about children's funds of knowledge and lived experiences outside of school spaces, making curriculum (especially mathematics) more culturally relevant, and including more opportunities for students to make choices and to play, or at least engage in play-like activities, including at upper elementary grades. In the scholarship on elementary TC learning, there are few articles on these topics that take a holistic or interdisciplinary approach in the way that the TCs in this study did.

Another implication of this work is that we need more research on how elementary teachers think about their positions as subject area generalists. This study investigated the thinking of a small group of white elementary TCs, but more perspectives are needed. What kinds of similarities do practicing teachers notice? Do their years of experience working in classrooms with children lead to different ways of thinking about connections? What roles do race, gender, class, sexual orientation, and other social identities play in how teachers think of similarities across subjects? And how might thinking about these similarities support elementary teachers in improving their practice in subject areas they are less comfortable with? Elanor's story, especially, seems to suggest that looking at a subject area she was uncomfortable with (i.e., mathematics) through the lens of a subject area she loves (i.e., language arts) helped her to see that the practices she was learning in her separate subject area methods course were not as different as they seemed at first.

The TCs made a variety of connections between mathematics and literacy, although they were not distributed evenly across the three categories of connection types. In the next chapter, I will analyze the contexts in which these connections were made to identify factors that encourage or limit connection-making.

CHAPTER 6: THE ROLE OF KNOWLEDGE BROKERS IN MAKING CONNECTIONS

In this chapter, I use ideas about the boundaries and connections between communities of practice (e.g., Star, 2010; Wenger, 1998; Yakhlef, 2007) to examine elements of the contexts in which the TCs were learning to teach that encouraged or limited opportunities to make connections between mathematics and literacy teaching and learning. In this case, I am conceptualizing the two methods courses as separate but overlapping communities of practice. By that, I mean that each course has its own practices related to learning to teach its particular subject, but they share some practices with each other and with teacher education more broadly. The focus group discussions served as boundary encounters between the two communities of practices, and the TCs in the study and I, as members of both communities of practice (i.e., mathematics and literacy methods courses), were positioned as potential knowledge brokers between the subject-area communities. I will begin with a short description of the three setting in which this study took place, then analyze the connections made in those settings more closely, beginning with the connections made in class sessions, and then the connections made in focus groups. I will use the ideas of boundary objects and knowledge brokers to compare the differences in the two types of settings then discuss implications for teacher preparation.

Settings: The Methods Courses and the Focus Groups

The connections between mathematics and literacy that the TCs made occurred in three settings: their literacy methods course, their mathematics methods course, and two focus group discussions. The same TCs were enrolled in both courses. Thirteen out of the 18 enrolled students agreed to participate in this study, and six of those thirteen opted to participate in focus group discussions.

In the elementary teacher preparation program, the TCs take one methods course in each of four subject areas during their senior year: science and social studies methods in the fall semester, and mathematics and literacy methods in the spring semester. There are multiple sections of each methods course, which typically have different instructors for each section. The instructors for each subject area meet together regularly with their subject-area leader during the semester they are teaching. In this study, the literacy and mathematics instructors met together a few times during the semester to coordinate course projects. This is unusual for this program, where instructors of different subject areas do not meet together other than an orientation at the beginning of the fall semester.

This study took place during the COVID-19 pandemic in the spring of 2021, and all university courses were delivered remotely. The literacy methods course met weekly on Zoom for an average of 60 minutes per session. I observed all sessions except for the first meeting, for a total of 12 sessions (approximately 12 hours). The instructor for the literacy methods course self-identified as a white woman and was interested in connections across curriculum. Her previous teaching experience included adult literacy classes and a variety of courses in the teacher preparation program. She had been the TCs' instructor for their social studies methods course taken the previous semester. The instructor was familiar with the subject areas of literacy and social studies, was interested in cross-curricular integration, and began the literacy course already knowing the TCs.

The mathematics methods course also met weekly on Zoom for an average of 90 minutes per session. Again, I observed all sessions except for the first meeting, for a total of 11 sessions (approximately 17 hours). The mathematics methods instructor also self-identified as a white woman and had taught a variety of courses in the teacher preparation program, including the

mathematics methods course and the literacy methods course. Her teaching background prior to the teacher preparation program included several elementary grade levels in which she taught all subjects. She had also been a literacy coach and a mathematics coach.

The third setting in which the TCs made connections between mathematics and literacy were focus group discussions outside of class time, which were part of this study and not a part of the typical undergraduate program. There were two focus groups organized by TCs availability. Four TCs participated in the first focus group, and two in the second. These focus groups met on Zoom for approximately one hour each. I was the facilitator for both focus groups. I am a white woman, and my teaching background includes many years in an elementary classroom, and a variety of courses in the teacher preparation program, including other sections of the mathematics methods course, and a reading assessment course that is a prerequisite for the literacy methods course. I had been the reading assessment course instructor for four of the TCs in the study, two of whom participated in the focus group discussions.

The vast majority of connections between mathematics and literacy were made during the focus groups (see table 10). Of the 79 total comments coded as an explicit connection between mathematics and literacy, 73 occurred in the focus groups. These were fairly evenly divided between the two focus groups, with the first 4-person focus group making slightly more (55%) than the 2-person focus group (45%).

In contrast, only six in-class segments were coded as explicit connections between mathematics and literacy, with three occurring in each course. This difference becomes even more striking when considering the number of hours covered by each context. The two focus groups met for about an hour each, for a total of two hours, compared to the courses, which met for a combined 29 hours. I had expected that the majority of connections across mathematics and

literacy would be made during the focus groups, but I was surprised by how few explicit connections were made by the TCs during class time.

Table 10

Number of Coded Segments by Category and Setting

Category	In Class ^a	In Focus Groups ^a	Total ^a
Curriculum Integration	0 (0%)	3 (4%)	3 (4%)
Language as Basis for learning	5 (83%)	23 (32%)	28 (36%)
Similarities and Differences	1 (17%)	47 (64%)	48 (62%)
Totals	6 (8%)	73 (92%)	79 (100%)

^a Totals may not match due to segments with multiple codes.

In the next section, I will go more in-depth on the context of the six in-class connections, situating them in the five episodes in which they were made. Then, I will describe the focus group context in more detail, followed by a discussion of the factors that seemed to encourage or discourage making connections across mathematics and literacy. Finally, I will conclude with some implications for elementary teacher preparation.

Making Connections in Class

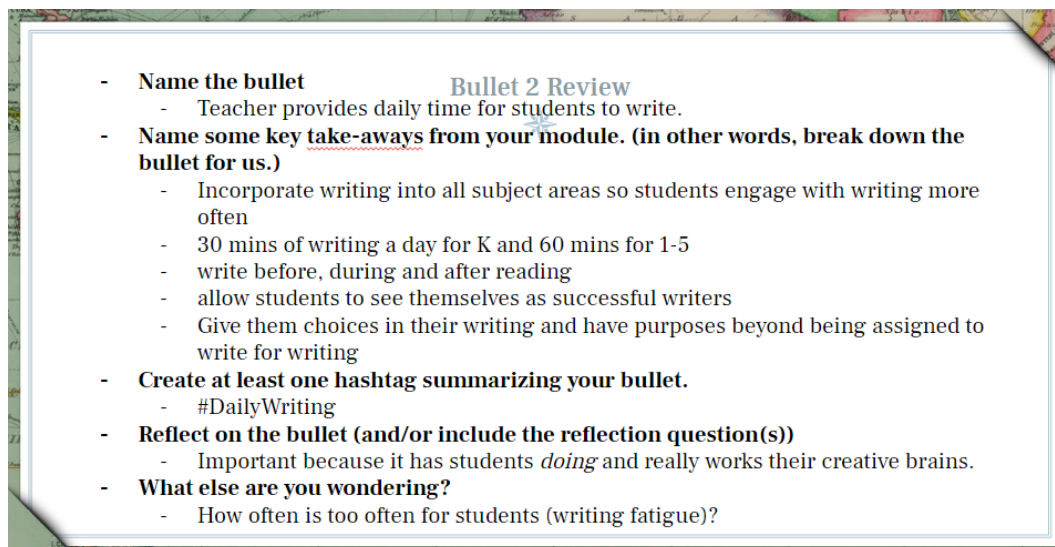
The connections between mathematics and literacy occurred in both methods courses, typically in response to a question or activity planned by the course instructor. Looking across all the in-class episodes, there is a mix of TCs reporting on someone else's brokering, participating in brokering activities assigned by instructors, and acting as brokers themselves. As I describe each of these episodes, I will identify the boundary objects and/or knowledge brokers that played a role in each connection.

Episode 1: Writing Across the Curriculum

This connection was a broader idea about how writing can be used across the curriculum, including mathematics. In the literacy methods course, the TCs divided up into groups to summarize different parts of the week's module about writing instruction, which included short articles about different aspects of writing instruction and video of teachers talking about their writing instruction. The group that summarized the section about daily writing reported their concern with the time required to write daily but thought that the teacher's suggestions for writing across the curriculum would help with that. Figure 4 shows some of their key ideas about writing daily.

Figure 4

TC's Summary of Assigned Module on Writing Instruction



Although they did not specifically mention how they might use writing in other subjects, they did think it was important to highlight the idea of using writing across the curriculum while presenting their summary to the class. The author's recommendation to incorporate daily writing into all subject areas and the teacher's examples of how she does that are acts of brokering across subjects, but the TCs did not seem to take this up, other than agreeing it would help meet the

recommended time for writing by spreading it across subjects. In their summary, they focused mainly on the benefits of daily writing, and not examples of using writing across the curriculum.

Episode 2: Math in a Picture Book

In a small group discussion in the literacy course, Marissa, Elanor, Lilly, Lindsay, and Alyssa were answering some reflection questions on their asynchronous work on how to structure a small group reading lesson. One question asked them to think about the ways that they (or their mentor teacher) supported children in activating their background knowledge before reading. After Marissa and Elanor had mentioned making predictions and previewing vocabulary, Lilly said that her mentor teacher connects a lot of subjects and gave an example of reading a book about astronauts in science and pointing out the ‘silent e’ words they had been working on. Lindsay added that her mentor teacher had done something similar with mathematics in the astronaut book. “There was something to do with math, I don’t remember what it was, but [the students] made connections, and she’s like ‘Oh, yeah, we were talking about numbers yesterday.’”

In this episode, the discussion reminded Lilly of the way her mentor teacher created opportunities to teach reading skills across the curriculum, which then sparked Lindsay’s memory of a cross-curricular connection with mathematics. The context of an elementary classroom, where the teacher teaches multiple subjects to the same children, creates opportunities for teachers and children to notice similarities across subjects, and Lindsay’s and Lilly’s mentor teachers used this opening to make those connections between subject areas. For Lilly and Lindsay, their mentor teachers’ practices served as a boundary object that allowed them to see the ways that subject areas can be integrated throughout an elementary classroom day.

Episode 3: Writing in Math

The next two segments happened in the mathematics methods course. An early assignment in the course asked TCs to write a math autobiography to explore their own experiences as mathematics learners. After it had been turned in, the instructor asked the TCs what they thought about the assignment. Elanor talked about what she enjoyed about the writing assignment.

Elanor: I like the integration of doing math with writing, because I'm a language arts focus, so it's kind of fun when you get a chance to do that. I went a little overboard, then realized at, like 1500 words and 5 pages that I should probably stop.

A few minutes later, Lindsay shared how the assignment had helped her reflect on her own feelings about mathematics.

Lindsay: I liked it a lot because I haven't really reflected on my math experiences in a long time. I'm a language arts focus so I haven't really taken any math classes in a while.

It just made me realize what I like about math, [and] what I don't like about math.

In their teacher preparation program, the TCs are required to pick a subject area as a teaching focus. Both Elanor and Lindsay mentioned that they are language arts focused, and Elanor said writing is a strength and fun for her, as evidenced by the length of her writing. This assignment seems to have given these two TCs, and perhaps others, an opportunity to use a strength in mathematics class in a way they had not experienced before. The instructor's choice to create an assignment that combined writing and mathematics served as a boundary object that created this opportunity for the TCs.

Episode 4: Reading and Listening to Word Problems

Another connection was made in mathematics methods course about the role of reading and listening in mathematics learning. The TCs were in breakout rooms after watching a series of videos of a child solving mathematics problems. In the videos, the interviewer read a math problem out loud to the child, and the child could choose paper, manipulatives, or mental math to solve the problem. The mathematics method instructor asked the TCs to talk about the types of word problems the interviewer gave, and the strategies the child used to solve them. As Lilly, Marissa, and Elanor were discussing the videos, they also talked about the way that the interviewer conducted the sessions.

Lilly: I was surprised that she didn't provide any written questions. I know that she made them on the fly with the dandelion thing, but even as an adult, I would probably ask them to repeat that, because some of those were lengthy questions.

Elanor: I would be like, "Wait, what was the number again?"

Lilly: That was - I feel like that was a situation that maybe could have - would have changed the number talk if she just had it written.

Elanor: I wonder if it's because she's not yet reading or if it would be more of a hindrance to have to stop and read the whole problem and decode and all of that stuff.

Lilly: I was thinking about that, and it's just, that's a super easy bridge that kids - like, teaching them the academic math language - once they learn how to read it, it'll make the solving of real math easier. That's one of those reading catches where children who are having trouble with reading, it impacts a lot of their other subjects, too.

Although the discussion in these breakout rooms was intended to be only about the mathematics, Lilly started a conversation about the role of reading and listening comprehension in solving

word problems. In this episode, Lilly and Elanor were both able to make connections between this mathematics course and what they were learning or had learned in another course. Lilly was also taking a methods course for teaching English to speakers of other languages (TESOL), which may have prompted her to think about the language demands of tasks in multiple subject areas, and Elanor appeared to be thinking about what she had learned about the relationship between decoding and reading comprehension in a previous course. By drawing on information from other communities of practice (i.e., other courses), they were acting as knowledge brokers in this episode.

Episode 5: Powerful and Meaningful Teaching

Episode 5 occurred in the literacy methods course. The class had just come back from breakout rooms where they had been discussing a reading assignment on vocabulary instruction that emphasized the importance of developing understandings of words rather than memorizing definitions. As they discussed the reading, they added questions to a shared document, and the instructor chose some of the questions to guide the whole-class discussion. After the instructor read a question about how to manage all the ‘moving parts’ of the instructional strategies they were learning, Elanor spoke up to clarify her question.

Elanor: In every [methods] class that we have, we go really in-depth on [a teaching strategy], whether it's powerful social studies, or no more look up the list [vocabulary], or number talks or science talks... I wonder, if you're supposed to do all of that within a day, how is that feasible? ...It just seems like it's so much to remember ... [The students] deserve to have that really meaningful teaching, but it's just a lot at the same time, so how do you make sure that you're always teaching powerfully and in an engaging way?

Though she is mostly expressing her concern about the time and mental energy planning and implementing these teaching strategies take, she is recognizing that these teaching practices being learned in separate communities of practice have something in common - they run counter to 'traditional' images of teaching and emphasize exploration and sense-making. Elanor was feeling overwhelmed by it because she was viewing them as separate practices with similar goals and had not yet considered how the practices themselves were similar.

Connections Between Math or Literacy and Another Subject Area

In addition to the six explicit connections between mathematics and literacy in these five episodes, there were four segments in which the TCs connected either mathematics or literacy with another subject area. I will briefly describe these here because they give a little more insight into when and how these TCs made connections across subject areas.

The first example took place in a casual conversation in a breakout room after finishing a class activity. Lilly and Kayla were talking about observing their placement classrooms on Zoom, and the difficulties of engaging children in that modality. Lilly shared how her mentor teacher used a lot of music with her first graders, and how enthusiastic the children were for any subject integrated with music. Lilly's mentor teacher appeared to be someone who frequently integrated subject areas and acted as a knowledge broker for Lilly by providing her with examples of different ways to integrate.

In another segment, Kayla made a connection between mathematics and science. In the mathematics course, the TCs were brainstorming answers to questions that parents might bring up about the kind of mathematics teaching they were learning about. One question was "Why isn't the teacher teaching?" The mathematics instructor clarified, "If you think about the format we've been using: launch, explore, discuss, why might parents see that as not teaching?". Kayla

pointed out that mathematics and science teaching are both inquiry-based, which means it is less likely that the teacher would be standing in front of the class and talking, which is what many people think of when they say “teaching.” Although the instructor only asked about this format in mathematics, Kayla recognized inquiry learning as a boundary object between mathematics and science. This seems similar to Elanor’s comment about powerful and meaningful teaching. Both Kayla and Elanor were noticing that multiple subjects had practices based on understanding content, rather than just memorizing.

The final two connections were made between social studies and literacy while creating a lesson that integrated those two subjects. The literacy instructor shared a children’s book, *Bowwow Powwow* (Child, Red Lake Ojibwe, 2018), and the TCs were tasked with creating a lesson based on the book that included both social studies and literacy learning objectives (see figure 3 in chapter 5 as an example). Although the TCs were able to find connections by thinking about the ways reading and writing could support social studies learning, Kayla and Elanor shared how they had a difficult time finding learning standards that would work well together in the context of a particular book, especially without a grade level to narrow down the choices. Daniel agreed but added that he thought social studies and literacy made a good pairing because of using reading and writing to learn about and make sense of social studies content. In this episode, the literacy instructor acted as a knowledge broker by setting up a learning activity that asked the TCs to look across the learning standards from more than one subject area, although they may have needed more time to make deeper connections between the subjects.

Something common across all episodes is their brevity and isolation. They were usually treated as isolated observations by a single TC and rarely led to extended conversations where TCs could make deeper connections between mathematics and literacy. The second-hand

brokering, when TCs were reporting their mentor teachers' practice or connections in their module work, was especially isolated, with each mention of connections only a sentence or two. One exception that was slightly longer than the others was Lilly's and Elanor's exchange about reading and listening to word problems. They engaged in collaborative brokering, each bringing information from another community of practice (i.e., TESOL methods course and reading assessment course) to make sense of the interviewer's choice to read word problems to the child and not provide written copies. Although this example is more complex than the other connections TCs made, it was still brief and isolated compared to the connection-making that occurred in the focus groups. Some of the brevity and isolation of the connections during class is likely due to the focus of each community of practice (i.e., methods courses) on learning to teach a particular subject. The pressure to get through a certain amount of material during a limited amount of class time likely also contributed to moving on quickly, particularly during the 2021 spring semester when synchronous meeting times were much shorter than usual for these courses in an attempt to avoid Zoom fatigue. Other factors could include the difficulty of having rich, whole class discussions without a few students dominating the conversation, which is intensified by the limits of using video conferencing like Zoom for larger groups. The typical class discussion format used by both instructors was framed as reporting on what the TCs discussed or did in breakout rooms, which seemed to encourage short statements, rather than more in-depth discussions. The focus groups offered a different type of opportunity to explore connections, having no required content to get through and very small group sizes, which made it easier to have the kinds of interactions required for rich discussions.

Making Connections in Focus Groups

The in-class connections that TCs made tended to be brief, isolated, and not explored in depth. In the focus groups, TCs engaged in rich discussions of connections across mathematics and literacy using collaborative brokering and brainstorming to make sense of the similarities. I will briefly review the structure of the focus groups, then give examples of the ways that the TCs engaged in making connections through knowledge brokering.

The two focus groups took place in the same week toward the end of the semester and were about one hour each. Lilly, Lindsay, Marissa, and Amelia met for the first focus group, and Elanor and Kayla for the second. Both focus groups had four main parts: (a) discussing what they thought was similar or different about teaching mathematics and literacy, (b) describing their vision for their future classroom, (c) responding to prompts based on in-class comments, and (d) thinking about drawing on teaching strengths across subject areas. As I describe the ways the TCs used collaborative brokering and brainstorming, I will discuss the role that these prompts played.

Brainstorming to Identify or Reinterpret Boundary Objects

One thing that knowledge brokers must do to make connections is to identify boundary objects that exist in both communities of practice. Brainstorming is a way to generate ideas, and the TCs used it in both focus groups to suggest things that might serve as boundary objects. It always happened in response to a direct or implied question. For example, in this excerpt from focus group 2, Kayla and Elanor had been describing their visions for their future classroom as places of respect, inclusivity, and fun. Noticing that they were only talking about literacy in their descriptions, I asked them how they saw mathematics playing a role in creating the types of classrooms they were describing:

Elanor: I'll be honest, I have less of a vision on how to do it with math than I do with literacy, however, I do want to keep exploring that ... because I think there is space in all subjects to be inclusive.

Kayla: Math is more of a hands-on type thing. ... Something I just came up with was maybe... I actually had a math journal in middle school, and ... you'd have to write down what did you learn ... I was able to look back and say, Wow, that's actually connected with this thing that we're going to do next, so I think that'd be really cool.

Elanor: Yeah, being creative with your math assignments and making them sort of practical, connected to life... I don't really have an idea off the top of my head, but maybe we were talking about fractions today, maybe bring a recipe that your family likes to make ... People can still share their own experiences and it's more relevant to them.

Kayla: Or an interview type thing, ... have students read out questions and just go around the school or the classroom and say, "How many siblings do you have? Or do you have any pets?" and do that type of thing. I don't know what that would be.

Elanor: You can do graphing with that stuff.

Kayla: Yeah, exactly.

Elanor: Yeah, collect information and stuff relevant to them, and then use that.

Kayla: And also for reading, you can find books that have problems with them, ... I don't know any of the top of my head, but ... a lot of them do have timelines and things like that within them.

Elanor: In my placement... the kids have a very hard time getting to page numbers in whatever book they're using, [like 397] ... these are first graders, and they're just learning about the tens place in the ones place right now. It makes sense that they don't understand

yet that going from this direction means the numbers are going to get higher. ... The numbers are everywhere and in everything, and I feel like you can tie that in into a discussion on place value.

In this excerpt, phrases like “I don’t know...,” “something I just came up with” and “top of my head” show that Kayla and Elanor are generating these ideas in the moment. What does not show well in the transcript is the tone of enthusiasm as they came up with ideas or took up the other’s thought to extend it or apply it in some new way. By collaborating in this way, they identified several potential boundary objects.

The other instances of brainstorming were not as quick and condensed as the previous example. They tended to show up as threads through the conversation, where the TCs continued generating ideas while also talking about other topics. Just like in focus group 2, when Lilly, Lindsay, Marissa, and Amelia were talking about their classroom visions, which centered around equity and social justice, they talked about literacy, and I asked them how they saw those ideas playing out in mathematics. Because the brainstorming was more drawn out in this excerpt, in the interest of space, I have summarized portions of the conversation in italics and focused on key quotes from the TCs.

Lilly: In one of my [other] classes, I'm doing a TESOL lesson using a translanguaging stance and incorporating literacy into another content area, and I actually chose math.

Lilly describes the activities she had planned in the lesson and some of the dilemmas she had, including choosing what objects to use in the mathematics story problems. She continues...

Lilly: In selecting all of my objects, I made them culturally relevant to students, and to their lives, ... and included different cognates of words that I knew that may be helpful.

Lilly describes her experience with interdisciplinary planning, which the others said was similar to their own experiences with the same assignment. Amelia returns to Lilly's previous idea:

Amelia: I was going to say something kind of similar to what Lilly said about finding artifacts...for a math lesson that can reach a wide array of students in your classroom... I feel like a lot of word problems and stuff that happens in math are very centered on the typical white experience that students have. I've been in classrooms before where students have just not understood part of a word problem. I've presented word problems to students and they're like, "I don't know what that thing is. What is that?" And it's a learning curve to realize that not all of your students have the same experiences and that you should be trying to present math in a way that makes it accessible to everybody, because as math stands right now, it's just not.

Lindsay: Also, going off of that a little bit, adding different ways of engagement is always beneficial too, whether that is videos or games... Movement is added, that makes it fun rather than it feeling like it's just school.

Marissa: Yeah, I agree. I think increasing accessibility for math learning and doing that by validating students' experiences and their sense-making abilities, for me, I feel very strongly about... The teacher needs to be the one to make it more accessible ... I think students, especially women or people of color, "struggle" in math because it's directed towards middle class white people.

As in the excerpt focus group 2, phrases like “going off what she said,” “I agree,” and “I was going to say something similar to...” indicate the way that ideas from other TCs sparks new thoughts for Lilly, Lindsay, Marissa, and Amelia in this context. Although this brainstorming is

not as rapid as Kayla and Elanor's, they are all generating ways to make mathematics more inclusive.

There were three other instances where I noticed this brainstorming pattern. Like the two above, most of the sessions started when I asked directly for ideas, such as how mathematics could support their classroom visions, or how they see writing playing a role in mathematics learning with children. For the other instance, the brainstorming started after Marissa and Amelia talked about how they wish mathematics was a more recursive practice like writing, and Amelia said, "Yeah, I have no idea how to do rough drafts in math. I have no practical application for that." This implied question prompted the others to begin suggesting ways that mathematics could be more like the writing process, including self-paced mathematics classes and collaboration similar to the process involved in publishing a book. One important factor in encouraging this brainstorming is the way the questions were framed. Commonly, in classroom settings, instructors at all levels ask questions to which they already know the answer and are checking to see if the students know it as well (Boyd & Markarian, 2015; Kosko et al., 2014). Even if this was not what was happening in these classes, most people have learned to expect that type of question in a class setting. In these focus groups, the questions were framed as a request for information that the asker did not have. For example, "How do you see that playing out in math?" is specifically asking for the TCs' views, which I would not know until they told me. They may also have seen Amelia's implied question about a practical application for doing rough drafts in math as a problem to solve and began mentioning possible solutions on how to do that. In both cases, they took up the questions as an authentic request for information.

Collaborative Brokering for Sense-Making

In addition to brainstorming, the TCs engaged in a more complex knowledge brokering that I call collaborative brokering. Some of the instances of brokering in the focus groups were brief, such this excerpt about normalizing mistakes as a part of learning:

Kayla: With the number talks, there's a perfect amount of wait time for every student, and you can explain your answer as well. It's not just the first answer, the first process... I think that also goes for reading, you don't want to tell kids what the actual word is. You want them to use the different processes of figuring out how to pronounce it, what it means.

Elanor: I think prioritizing the process over the product is really important, and that helps kids who maybe wouldn't be willing to share because they're worried about having wrong answer.

After this brief exchange in which Kayla identifies teaching practices in reading and mathematics that normalize mistakes, they went on to talk about another topic. However, most of instances of brokering that took place were much longer and more collaborative. For focus group 1, the collaborative brokering happened over longer conversations, with the TCs returning to something someone else had said earlier. In this example, Lindsay mentioned early in the discussion that she has learned a lot about how to be more inclusive in teaching, but that idea was not taken up again until several minutes later in the discussion.

Lindsay: I am in the TESOL program, and I think I have learned a lot about being more inclusive and more... open to change within the lesson.

After Lindsay's comment, the conversation turns to a discussion of how they are learning ways of teaching that are very different from and more effective than the ones they

experienced. When I asked about their visions for their future classrooms, Marissa took up the idea of being inclusive:

Marissa: I personally would like to teach more in the style of inclusive, renegade teaching for literacy, introducing books like... What's the metaphor? Books are mirrors. Books are windows. Yeah, so windows into other [life] circumstances... But [also] making them see the connections between how literacy can be used as kind of a tool for good and social justice.

Amelia: I share a lot of the same sentiment as Marissa, and especially in the younger grades... foundations for reading start at that age. I was a kid who always loved reading, but that was because I saw myself in books all the time. I was a little blonde middle-class girl. There are students who hate reading and for good reason... They're not seeing themselves represented in the text in classrooms. So I think a big thing for me is ... making sure that students have access to not only books that represent them, but also their classmates and anyone they're going to meet in the world.

Lindsay: I was going to say something very similar, because kids are sponges, and I feel like as elementary school teachers, we definitely forget that they are capable of many things... they understand everything we are saying... so being culturally aware with whatever literacy tools you are utilizing.

Marissa: I think also with literacy, being a TESOL minor, being able to teach students the power structures within a language, and validating African American Vernacular, and also any type of slang... Teaching them to code-switch in those ways so that they don't have to let part of their culture or background go in order to succeed... For me, talking a

bunch of linguistics classes in college really taught me just how much my own personal biases in the way someone speaks affects my opinions of them.

In this example of collaborative brokering, the TCs were bringing knowledge from other courses they had taken or were currently taking to build an understanding of what is involved in creating an inclusive classroom. Lindsay brought in information from her TESOL methods courses, and Marissa brought her learning about linguistic bias into the conversation. The mentions of having children's books that represent the children in the classroom is an idea that was emphasized in the reading assessment course, along with the foundations of reading. Through this collaborative brokering, these TCs were able to bring these ideas together in a way that might not have occurred to them individually. They did not include mathematics in this brokering. When I asked them about mathematics, it led into the brainstorming session described in the previous section of this chapter.

The collaborative brokering in focus group 2 had a different quality than the brokering in group 1, likely because I unintentionally facilitated the groups a little differently. I conducted the first focus group as an interview, asking questions to get them started talking or to ask clarifying questions, but for the most part, I stayed out of their conversations. In contrast, I started the second focus group by saying, "What I want to do is just have a conversation about connections between math and literacy." Because of this different framing, I participated in the collaborative brokering. This excerpt shows how Elanor, Kayla, and I engaged in collaborative brokering around reading word problems.

Elanor: Another similarity is the importance of language and, in respect to speakers of other languages, that will have an impact both in math and literacy... Because reading is

involved in every subject area, same with speaking, just all of the language skills are involved in all subject areas.

Kayla: Yeah, for sure. And story problems, ...I think if you can understand what the story problem is trying to say and what the question is, that's an important comprehension skill as well as the vocabulary that's present.

Elanor: Right. In our math interviews that we did earlier, ...each of the students we worked with had different levels of reading proficiency, and that impacted their understanding of the problem. ... If they are not yet able to read some of those story problems, ... [it] really impacted how they did the math.

Lisa: (facilitator) It sounds like you're thinking about word problem as a specific genre of reading, would you say that?

Elanor: Yeah, it's definitely a particular type of writing. The way that they're written, it's not like reading an informational text or a story. It's its own sort of thing, that students have to be familiar with the structure.

Kayla: It's almost like a critical thinking question: you're taking the content that you've been learning and then you are thinking about it in a different format or a more real life-based, ...it's just worded differently.

Elanor: And that wording can really impact how students go about solving ... It's different than just seeing an equation on paper.

The knowledge brokering in this excerpt is complex. Elanor started by bringing in knowledge from another community (i.e., her TESOL methods course) to acknowledge the role of language in all learning. Kayla took that idea and connected reading word problems to what she knew about reading comprehension from a different community of practice (i.e., the previous reading

assessment course). I was familiar with the content of the reading assessment course, having been a member of that community as Elanor's instructor (but not Kayla's), which allowed me to make the connection between Kayla's comment about reading comprehension and material in the reading assessment course about the differences in reading different genres. We returned to the idea of reading in mathematics later in the conversation, and Kayla and Elanor continued to use their knowledge of learning to read to make sense of why students had difficulty understanding word problems.

Elanor: I think this goes back to what we were talking about in the beginning, is that relationship with reading in all subjects... With the math interview... some of the students were having to try and decode... and that was affecting their confidence level going into solving a math problem.

Kayla: We had a similar thing happen with our math interview, and [when I] tutored over the summer last year... They would always read [the book] really well, but then the comprehension part - there was a quiz at the end - and they would sometimes forget all the information and you can't go back [to the book]... so I think that [reading comprehension] does have an effect on everything.

Elanor: And if you're devoting all of your time when you're reading ... to decoding rather than comprehending... Like you said, they might read it pretty okay, but if their attention is directed at getting the sounds right and not at "what am I actually reading?" ... that impacts your comprehension.

In this episode, each of our multi-membership in communities of practice allowed us to bring knowledge from those contexts to this conversation, collectively brokering knowledge across communities of practice to make sense of how children read word problems. Another instance of

this complex, collaborative brokering took place in a discussion about the importance of choice in learning, where I again made a connection to an idea from that reading assessment course.

Elanor: As a student I definitely would enjoy doing things where I was given a choice... that made it more interesting to me.

Lisa: (facilitator) I'm thinking... I know Elanor read this article in [the reading assessment course], but Kayla, did you read that? It was the 6Cs of motivation article... These quotes make me wonder ...about the other Cs, which I can't remember all of them...

Their conversation about the way that having choice made learning more interesting, along with the brokering from the reading assessment course earlier in the conversation, reminded me of an article from that course about motivation in literacy learning (Turner & Paris, 1995) where having choice was one factor in motivation. Mentioning this article, which both Kayla and Elanor had read, prompted a wider discussion of motivation in learning. After the three of us tried to remember all 6 of the Cs, and Elanor looked them up for us, "Okay, yeah. So, it's choice, constructing meaning, control, challenge, consequence and collaboration," Kayla shared her experience with a project that incorporated mathematics and reading in learning about nutritional information, and how that made the learning more interesting. Then, Elanor elaborated on another of the factors of motivation from the Turner and Paris (1995) article.

Elanor: I think you can find ways for those to apply across math and literacy, too, like constructing meaning. We are talking about sense-making today with math, and then reading comprehension is ... also constructing meaning... That's also something we talked about in science, the fact that really what students are doing when they're learning

new things is just making sense of phenomena that exists, and so yeah, that definitely applies across all subjects.

In Episode 5 of the in-class connections, Elanor had noticed that some of the teaching practices she was learning across all the content-area methods courses were powerful and meaningful ways to teach. At the time, she had not yet thought about the ways in which those practices were similar. The collaborative brokering in this discussion allowed her to think about those practices in a different way. With the support of the three of us noticing that choice is a factor in motivation across the curriculum, and my wondering about whether the other factors of motivation applied across as well, Elanor realized that all of those “powerful and meaningful” teaching practices were about supporting children in constructing meaning.

Discussion and Implications

The TCs in this study were able to make many connections between mathematics and literacy. The focus group discussions generated more connections that went deeper than in-class activities. There are a few features of the focus groups that supported the more in-depth connections. First, the focus groups can be considered boundary encounters, spaces outside of both methods courses set aside specifically to think about similarities across subject areas. Boundary encounters like the focus groups are spaces where the constraints of the communities of practice are loosened and this makes connections across communities more possible (Lam, 2018). In this case study, the methods courses function as separate communities of practice, likely perceived as separate spaces to learn about teaching literacy and about teaching mathematics, respectively. This perception may have limited TCs connections across subject areas, despite the instructors’ interest in and mention of connections across the curriculum. The

focus groups, in contrast, were free of the constraint of focusing on learning to teach a particular subject and were more open to thinking more holistically across subjects.

A second feature is that brokering between communities of practice requires the broker to recognize similarities in both communities. The more “distant” those communities are perceived to be, the more difficult it can be to see the similarities. For example, the literacy methods, TESOL methods, and linguistic courses are closely related fields. In the less directed parts of the focus groups, the TCs made many connections across these courses, brokering ideas from TESOL and linguistics to add to their discussions. This happened less frequently with mathematics, which is typically perceived as very different from literacy and language (Matthews & Rainer, 2001). When prompted to talk about the role of mathematics in the topics under discussion, the TCs were able to make connections, but they needed that support to do so.

A third factor that made the focus groups distinct from the class sessions was the presence of a more experienced knowledge broker. In both groups, one way I acted as a knowledge broker was by choosing ideas that TCs had mentioned from each class to use as more structured prompts. I used my knowledge of similarities between the two subjects, gained through many years of elementary teaching, as well as through my scholarly work, to support the TCs connection making by bringing some of those similarities to their attention. In focus group 2, I went further in my role as a knowledge broker by participating in the collaborative brokering and connecting the things that Kayla and Elanor were saying about one subject area to the other. This more active brokering on my part led to the TCs making connections between the subjects that were deeper and more conceptual than with other kinds of support. Although the course instructors both engaged in knowledge brokering between mathematics and literacy (i.e., 62 times across the two courses), it was nearly always initiated by the instructor and framed as

identifying a boundary object. In the focus groups, I was freer of the constraints of time and curriculum than the course instructors, and my relationship with the TCs was not that of a current instructor who would be assigning grades, but as a person who was interested in hearing their thoughts about similarities between the two subjects, and in focus group 2, as someone wanting to have a conversation about similarities. As a result, my knowledge brokering was taken up as a contribution to the collaborative brokering, rather than as a teacher stating a fact.

All the TCs in the focus groups engaged in knowledge brokering at some point, although some did it more than others. Wenger (1998) observed, “Although we all do some brokering, my experience is that certain individuals seem to thrive on being brokers: they love to create connections and engage in ‘import-export,’ and so would rather stay at the boundaries of many practices than move to the core of any one practice” (p. 109). That was true of the TCs in this study, and I would also add that their positions as novices to the practices of elementary teachers made it more difficult for them to see those connections without the support of a more experienced member of the elementary teaching community of practice.

Implications for Elementary Teacher Preparation

The typical way of structuring elementary teacher preparation program, with separate methods courses in each subject area, assumes that, if they need to, the TCs will automatically make connections and notice similarities across subject area. This study suggests that does not happen often in the natural course of events. In many ways, the methods courses observed in this study represented best-case scenario, or what Flyvbjerg called a “most likely case” (2011) for supporting TCs in making connections between mathematics and literacy. Both instructors were interested in and experienced with cross-curricular work, were members/instructors of more than one subject area community of practice in this teacher preparation program, and frequently

mentioned similarities between subject areas during class. The instructors met together and coordinated assignments across the two courses, and the same TCs were enrolled in the same sections of all four of their subject area methods courses. None of these factors are common in the teacher preparation program in which this study takes place. Despite being more conducive to knowledge brokering between subject areas than typical methods courses, there were only two instances where the TCs acted as knowledge brokers themselves during the class meetings. For the other in-class connections, either the instructor was the one who made the connection between subject areas with the TCs taking it up, or the TCs were reporting on their mentor teacher's brokering.

In contrast, the focus group interviews featured many connections across subject areas, with the TCs acting as the knowledge brokers collaboratively with each other and with my support as a more experienced knowledge broker. This suggests that, in order to make connections across subject areas, TCs need the space to do so, and the support of someone who is, at minimum, aware of the practices of the multiple subject areas taught by elementary teachers, or, ideally, someone who holds multi-membership in all of those communities of practice.

CHAPTER 7: CONCLUSION

Some might ask why elementary teachers and TCs need to make connections across subject areas. Isn't it enough to become experts in teaching each subject area? I argue that there are at least three reasons: a) children benefit in many ways from integrated curriculum, b) reading can be a barrier to mathematics for some children, or at least a barrier to expressing their understanding of mathematics, and c) being aware of similarities in pedagogy reduces the cognitive load of teaching multiple subjects and can boost teachers' confidence in teaching all subjects well.

Integrated Learning

There is a great deal of research on the benefits of integrating learning for children. In general, integrating any two (or more) subject areas increases children's learning in both subjects and creates more positive feelings towards those subject areas (see Cunningham, Kantrowitz, Harnett, & Hill-Ries, 2014; Fantuzzo, Gadsden, & McDermott, 2011; Paprzycki et al., 2017 for mathematics and literacy integration). In this study, the TCs created an integrated social studies and literacy lesson, and Lilly and Elanor reported creating integrated mathematics and language lessons for the TESOL course. Similar to Boche and colleagues' (2021) study, the connections the TCs made were about using children's literature to support social studies learning, and adding language support for emergent bilingual students to a mathematics lesson, rather than deeper conceptual connections between the two subjects. For the TESOL projects, this makes sense, as the goal was to learn how to support multilingual students' learning. For the social studies and literacy lesson, the TCs had a very limited time to create the lesson and talked about the difficulty of finding appropriate learning standards, likely due to lack of familiarity with the standards. In addition, while describing her integrated TESOL project, Lilly mentioned that she

found the process “intimidating” at first but felt more comfortable as she read the standards and found connections.

This suggests that the TCs needed more time and guidance to examine content standards and compare them across subject areas. This is consistent with Matthews and Rainer’s (2001) study with practicing teachers, who started with surface-level similarities between mathematics and literacy, and then, with more time and a bit of a ‘nudge,’ as Matthews and Rainer called it, they were able to make deeper and more conceptual connections between mathematics and literacy. These teachers, and the TCs in my study, needed someone with knowledge of both subject areas to act as a knowledge broker to ‘nudge’ them to notice similarities, and well as the time to analyze and compare literacy and mathematics learning.

Disciplinary Literacy

The TCs in this study were very aware of the ways that reading can be a barrier to mathematics, or to demonstrating mathematical knowledge, for many children. Amelia, Lilly, Elanor, and Kayla all shared stories from their placements or other experiences about the ways that reading affected students’ mathematics performance. Their initial ideas for supporting students, when they offered any, was to read the mathematics aloud. Although this is one helpful strategy for eliminating that barrier, they did not bring their knowledge of how children learn to decode and comprehend text until two knowledge brokers, Kayla and myself, connected reading comprehension and mathematics word problems. This prompted some talk about vocabulary, background knowledge, text structure, and other factors that influence reading comprehension, and the need for supporting children with those skills in mathematics. Doerr and Temple (2016) noticed the same thing with the teachers in their study. The teachers had background knowledge about reading and reading comprehension strategies, but did not use it with mathematics texts

until they participated in the PD. I argue that this was because they needed a knowledge broker to make that connection and nudge their thinking in that direction, which means instructors of elementary mathematics methods courses must have at least a basic understanding of strategies for supporting novice readers.

Drawing on Strengths

A third reason I would argue that elementary teachers need to make connections across subject areas is to be able to draw on their strengths as teachers to teach subjects they are less comfortable teaching. This is particularly important for mathematics, as it tends to be the subject elementary teachers are least comfortable teaching (Buss, 2010; Gerde et al., 2018; Wilkins, 2010). Elanor's case demonstrates why making connections across subject areas can be a way to ease math anxiety.

Early in the semester, Elanor was concerned about being able to teach in the ways she was learning in her methods courses. She recognized that the practices she was learning were focused on sense-making, and she understood that children needed and deserved that kind of instruction, but she couldn't figure out how to manage all the "moving pieces." The cognitive demands of implementing all of these separate (as she saw them) practices was overwhelming. It was in the focus group, a space set aside specifically for thinking about similarities between mathematics and literacy, that she started to make deeper connections between the practices. It started with recognizing word problems as a genre of writing; suddenly, teaching children to read word problems was no longer a separate practice, just an application of what she already knew about reading comprehension to a different type of writing. Then, she explicitly made the connection that all the subjects focused on sense-making, so that when she started talking about what she loves about writing – that it's a recursive process – she realized that her mathematics

methods instructor had talking about process learning, and that it meant the same thing: producing initial ideas and changing them. Finally, when Kayla said that sharing solutions in mathematics class is like listening to people's perspectives on books, Elanor immediately grabbed on to that idea as something she liked to do and was good at. In the space of a one-hour conversation about similarities between mathematics and literacy, Elanor went from feeling anxious about teaching mathematics and overwhelmed by the number of teaching practices she was learning to realizing that she could draw on strengths such as the writing process and discussing perspectives and transfer them to her teaching of mathematics. Without the time set aside for thinking about connections, and without my and Kayla's knowledge brokering, it is doubtful whether Elanor would have made this connection.

Implications for Elementary Teacher Education

In this dissertation, I have explored the types of connections between subject areas, the conditions which encourage connections, and why making connections across subject areas is important for elementary teachers, and demonstrated that they need space, time, and the support of a knowledge broker to make those connections. The problem is that teacher education is not typically organized in ways that promote making connections. A typical structure for an elementary teacher preparation program is separate subject area methods courses taught by subject area specialists. Separate subject area methods courses encourage staying within the boundaries of those communities, and subject area specialists are likely not familiar with teaching methods for other subject areas. Even with both instructors in this study familiar with more than one subject area and interested in cross-curricular connections, very little connecting took place within their courses.

I argue that TCs need intentionally planned spaces for thinking more holistically about elementary teaching and making connections across subject areas. Methods courses that integrate more than one subject area are one way to create these spaces. Some opportunities could be incorporated into separate methods courses; for example, analyzing mathematics texts as a genre and thinking about what skills students need to decode and comprehend it. Other types of connections, such as integrated curriculum, could be accomplished through collaboration between instructors of separate courses, such as a shared project to create integrated lesson plans, or coordinating course topics across the two courses. Another possibility could be something that functions as a boundary encounter between subject areas, such as discussion groups outside of the separate methods courses.

In addition to intentionally creating spaces for making connections, I also argue that elementary TCs need instructors who can act as knowledge brokers, making connections across subject areas. Some ways to accomplish this could be subject area specialists co-teaching integrated methods courses, each bringing their knowledge to the course (e.g., Draper & Siebert, 2004), or co-planning separate courses so both instructors are familiar with the learning goals and activities of the other course. Gillis and colleagues' (2016) study of subject-area teachers sharing expertise is an example of how this can happen. At first, the mathematics teachers were responsible for planning mathematics content, and the literacy specialists looked for opportunities to use literacy strategies in the mathematics lessons, but over time, the mathematics teachers began to notice more and more of the opportunities for literacy in their own mathematics lessons. Draper, a literacy educator, and Siebert, a mathematics educator, (2004) experienced something similar when they conducted a cooperative inquiry into the use of literacy in Siebert's undergraduate mathematics course, each learning more about the other's specialty.

These types of boundary encounters with experts from other subject area communities of practice can support instructors in acting as knowledge brokers for the TCs in their elementary methods courses.

Teacher educators with a background in elementary education have an advantage as knowledge brokers between subject areas. Rather than needing boundary encounters with others in subject area communities of practice, we are members, even if only peripherally, of multiple subject area communities. We live in the boundaries between subject areas, and thus, are positioned to notice connections and act as brokers for others. The wide content knowledge of elementary teachers is often critiqued in mathematics education research as being a deficit compared to the deep knowledge of secondary teachers. When viewed through the lens of connections across subject area communities of practice, wide content knowledge is a strength, and more, it is *necessary* for making connections across subject areas, for elementary teachers and for elementary teacher educators.

Future Scholarship

As I reflect on what I have learned through this dissertation and how it might carry into my future work as a scholar and teacher educator, I am excited about the uniqueness of the position I'll be taking in the fall and the way it seems ideal for continuing this work. I will be joining the math department at Grand Valley State University as an assistant professor of mathematics education, but also as a member of their new interdisciplinary major for prospective elementary teachers, called Pedagogical Content Knowledge for Elementary Teachers (PCKET). This opens some exciting possibilities for collaboration across subject areas. One of my future colleagues, Dr. Paul Yu, shared a project he did with the students in his geometry course, where they created picture books on a geometry topic. One possibility for future cross-discipline

collaboration could be to expand a project like this to make it a shared assignment across the mathematics course, a literacy course, and a visual arts course, where each discipline contributes something unique to the project. The PCKET program also opens an opportunity to coordinate topics across courses, perhaps arranging them in ways that would support connections among different subject areas.

In the mathematics methods courses that I teach, I plan to create opportunities for the prospective teachers to think about connections between mathematics and other subject areas, and I hope to study the ways that the prospective teachers take this up, and whether noticing these similarities changes the ways that they think and feel about mathematics. I am also interested in studying the mathematics teaching of students like Elanor, whose connection-making causes them to feel more confident about teaching mathematics, to see if that new confidence translates into more inquiry-based teaching practices.

Something that has bothered me since I started this doctoral program and began reading the mathematics education literature is the prevalent view of elementary teachers' broad content knowledge as a deficit. Too many studies focus on the mathematics that elementary teachers do not know and dismiss their knowledge of other disciplines and of child development. I think one of the most meaningful things for me about this dissertation is the way I've been able to articulate why broad content knowledge is important for elementary teachers and develop an argument for viewing that as a strength. That is what has held me back from making a full-on critique of those deficit views of elementary teachers' knowledge, and now... well, I definitely won't be letting those deficit-oriented Tweets slide by anymore.

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