The Role of Mental Models in Sensemaking during the Data-Driven Decision-Making Process and Their Impact on Instructional Practice

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THE ROLE OF MENTAL MODELS IN SENSEMAKING DURING THE DATA-DRIVEN DECISION-MAKING PROCESS AND THEIR IMPACT ON INSTRUCTIONAL PRACTICE

by

Ann M. Bingham

A dissertation submitted to the Graduate College in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Educational Leadership, Research, and Technology Western Michigan University
December 2019

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THE ROLE OF MENTAL MODELS IN SENSEMAKING DURING THE DATA-DRIVEN DECISION-MAKING PROCESS AND THEIR IMPACT ON INSTRUCTIONAL PRACTICE

Ann M. Bingham, Ph.D.
Western Michigan University, 2019

Data-driven decision making (DDDM) is a practice that has been shown to improve student achievement. However, the success of this process relies on the mental models applied during sensemaking. The purpose of this multiple case study was to describe and interpret how elementary mathematics teachers made sense of data from the Delta Math readiness screener. Additionally, this study captured the types of changes that teachers made as a result of analyzing this particular data source.

This study employed qualitative methods to determine the mental models that teachers applied during DDDM. These methods also provided participants an opportunity to describe how their instruction changed as a result of data dialogues. Primary methods of data collection were observations and semi-structured interviews. Participants were selected from a school district in Michigan that utilized the Delta Math readiness screener and provided time for teachers to analyze the data.

During the 2018-2019 school year, three fourth-grade teachers from an elementary school in southwestern Michigan began their initial implementation of the Delta Math Readiness screener. Before implementation, each participant was interviewed to better understand how they typically applied mental models to various data sources and the types of instructional change employed. The participants screened their students in the fall, winter and spring using the Delta
Math Readiness screeners. Upon the conclusion of each screening, observations of the grade level data reviews were conducted, along with follow-up interviews.

This study confirmed much of the research conducted in previous studies and contributed new findings that could be useful in elevating the practice of data-driven decision making. During the 2018-2019 school year, all four mental models, including instruction, student understanding, nature of the test, and student characteristics, were applied. Mental models associated with instructional change were applied more frequently than those that are not associated with instructional change. Interestingly, this study demonstrated that a teacher could apply a mental model associated with instructional change in conjunction with a mental model not associated with instructional change and a change in instruction could still occur. Of significant interest, this study revealed a potential fifth mental model, prior instruction. This model seems to occur when teachers attribute student outcomes to the quality of instruction received in prior grade levels.

This study also provided a detailed description of the types of instructional changes employed and confirmed the four types of instructional changes articulated in the literature. Additionally, this study revealed new changes in instruction including (a) reward system, (b) reprioritization of core content, (c) strategic intervention planning, (d) more frequent formative assessment, and (e) realignment of Tier 1 and Tier 2 content.

This study has furthered the discussion around data-driven decision making by calling attention to a screener that promotes the application of mental models that are associated with instructional change. Those in K-12 leadership roles can benefit from this research, as they make decisions around the data sources that empower practitioners to engage in new techniques that bolster student achievement.
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CHAPTER I

INTRODUCTION

“Data will talk to you if you are ready to listen” (Bergeson, 2013, p. 2). Data-driven decision making is a practice that has been shown to improve student achievement. However, the success of this process relies, in large part, on the mental models educators apply during sensemaking. Interestingly, the application of certain mental models results in a change in instruction while the application of others does not. This qualitative study enriches scholarly dialogue by providing a rich description of various mental models applied to data obtained from a universal screener, Delta Math. Additionally, this study provides greater insight into how teachers changed their instruction based upon the application of mental models to this specific data source.

Background

In the age of accountability, student achievement data has become the central focus for instructional decisions (Jacobs, Gregory, Hoppey, & Yendol-Hoppey, 2009). No longer should teachers base their decisions on intuition and prior experience. Instead, federal legislation, such as No Child Left Behind (NCLB) and the Every Student Succeeds Act (ESSA), has served as a catalyst to engage the K-12 community in a practice known as Data-Driven Decision Making (DDDM). DDDM requires teachers, principals, and administrators to systematically collect and analyze various types of data, including input, process, outcome, and satisfaction data to guide a range of decisions to help improve the success of students and schools (Marsh, McCombs, & Martorell, 2006). While this practice was initially mandated by policy makers, decades of research indicate that the use of student data is positively correlated with a variety of student
achievement measures (Airola & Dunn, 2011; Earl & Katz, 2002; Evans, 2009; Fuller & Johnson, 2001; Scheurich & Skrla, 2003; Stringfield, 1994; Wayman et al., 2006; Weber, 1971). The messages around DDDM are very clear: Those who can engage and implement the practice successfully will find noticeable improvement in student achievement across all academic disciplines.

While research has demonstrated that DDDM has a positive impact on student achievement, this process is subject to the mental models that teachers apply during sensemaking. Sensemaking is the process by which individuals and groups make meaning of new experiences and ideas, particularly during times of ambiguity or uncertainty (Farrell & Marsh, 2016). Within sensemaking, mental models, which are comprised of assumptions, definitions, and beliefs around a concept, are applied. Mental models also impact the types of responses teachers employ in response to data (Johnson-Laird, 1986; Senge, 2006). Types of instructional response include reteaching, regrouping students, having students reflect on their data, implementing changes in instructional delivery or no change in instruction. Interestingly, different forms of data can also impact whether or not a teacher engages in instructional change (Farrell & Marsh, 2016).

As the focus of building principals and district administrators has shifted from management to instructional leadership (Halverson, Grigg, Pritchett, & Thomas, 2007; Neumerski, 2012), it is important that they support teachers in making sense of data in ways that allow them to respond intentionally. With this in mind, instructional leaders must consider the types of professional development that will empower teachers to make sense of data in meaningful ways. Additionally, knowing that data type impacts instructional response, district
and building leadership must prioritize, if not lessen, the myriad assessments that teachers are required to analyze.

**Problem Statement**

In theory, DDDM is simple. Teachers identify what students know via the available data and adjust their instructional practices accordingly. These adjustments in instructional practice are designed to yield an overall improvement in student achievement. However, the underlying assumption is that data are seen as neutral, objective, and safe from the politics and ideologies of schools and school systems (Henig, 2012). Farrell and Marsh (2006) contend that “in this view, data are often treated as a monolithic entity, with little attention paid to the types or sources” (p.12).

While DDDM has been shown to have a positive impact on student achievement, it is a complex process that is driven by the beliefs and past experiences of teachers (Spillane, Reiser, & Reimer, 2002). Additionally, the success of this process is dependent upon how teachers make sense of outcomes observed in the data. For instance, a teacher may attribute low test scores to prior instruction or to perceived student deficits. Because these attributions are outside the perceived control of the teacher, the data may be perceived as irrelevant and a change in instruction will not occur (Datnow, Park, & Kennedy-Lewis, 2012). While the purpose of DDDM is to empower teachers to change their instructional practice, the role that beliefs and prior experiences play in this process must be attended to if the intended outcome is to be realized.

The complexity of this process is further compounded by the fact that teachers are bombarded by multiple sources of student-achievement data. In the state of Michigan, districts may utilize the following sources: Scholastic Aptitude Test (SAT), Michigan Student Test of
Educational Progress (M-STEP), Northwest Evaluation Association (NWEA), local interim assessments, AIMSWEB, classroom assessments, and the Delta Math Response to Intervention (RtI) Program. This myriad of data can make sensemaking difficult, which, in turn, may impact a teacher’s ability to change instructional practices. It is imperative that the instructional leader simplify the process by prioritizing the types and sources of data that teachers utilize (Bernhardt, 2004; Breiter & Light, 2006; Datnow & Levin, 2012; Datnow & Park, 2014; Meile & Spillane, 2007).

Bertrand and Marsh (2015) found that during DDDM teachers activate four distinct mental models of sensemaking, including instruction, student understanding, the nature of the test, and student characteristics. Teachers possess mental models that are comprised of assumptions, definitions, values and beliefs, and subsequent actions or perceptions that proceed from this framing (Fauske & Johnson, 2003, Johnson-Laird, 1986; Senge, 2006). Mental models are not static and can be influenced by external factors, such as whether or not the teacher had input in creating the assessment or the characteristics of the students they instruct.

Interestingly, these models have implications for teacher motivation to change instruction. The first two models, instruction and student understanding, were shown to have a positive impact on instructional change while the last two models, the nature of the test and student characteristics, did not. Moreover, as instructional leaders navigate the various sources of student achievement data, it would be helpful to identify those sources that activate mental models associated with positive instructional change. Therefore, this study explores the interplay among mental models, sensemaking, and instructional change.
Studies Addressing the Problem

Data-driven decision making (DDDM) is a complex process in which data are systematically collected, analyzed, examined, and interpreted in order to inform practice and policy within schools (Mandinach, 2012). As both teachers and administrators engage in this process, the underlying belief is that utilizing data to make a variety of decisions will improve a child’s access to quality instruction. Regardless of the type of data, DDDM is seen as a cyclical or iterative process of identifying a problem, determining possible solutions, and monitoring the implementation of the solution.

Decades of research support that the use of student data is positively correlated with a variety of school factors including improved professional collaboration, more varied instructional practices, and increased student achievement. For example, Carlson, Borman, and Robinson (2011) found significant increases in mathematics achievement along with notable increases in reading achievement after a year of data-driven reform guided by the Johns Hopkins Center for Data-Driven Reform in Education.

While there are several examples of the positive effects of data-driven decision making, Marsh et al. (2006) contend that most of the research on this topic has examined the implementation of DDDM. As a result, districts that attend to the following strategies: building a foundation for data-driven decision making, establishing a culture of data use and continuous improvement, investing in an information management system, selecting the right data, building school capacity for data-driven decision making, and analyzing and acting on data to improve performance can better support the implementation of data-driven decision making.

Not only must districts attend to the systems and conditions necessary to support DDDM in schools, they must also address the individual needs of the teacher. As previously mentioned,
assessment data have the potential to inform how teachers plan lessons, identify concepts for reteaching, and differentiate instruction (Hamilton et al., 2009; Kerr, Marsh, Ikemoto, Darilek, & Barney, 2006; Supovitz & Klein, 2003). Yet, how teachers actually use data to shape their decision-making around their instructional practice is not entirely understood by the broader research community (Coburn & Turner, 2011; Little, 2012).

Research has demonstrated that a lack of training will limit teachers’ capacity to use data effectively. However, as Farley-Ripple and Buttram (2015) explain, “there is little evidence on how capacity for data use develops” (p. 2). Gummer and Mandinach (2015) better describe this capacity as data literacy. Teachers who are data literate have the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting various types of data as a means to determine instructional steps. Absent sufficient training, teachers lack confidence in their ability to use data to improve instruction. Research indicates that most teachers tend to be underprepared, anxious (Volante & Fazio, 2007; Wayman, 2005), and lack confidence in their abilities to engage in DDDM (Bettesworth et al., 2008).

Moreover, capacity-building efforts have focused primarily on the individual and organizational levels, rather than addressing how capacity is embedded in social relations (Farley-Ripple & Buttram, 2015). Gummer and Mandinach (2015) acknowledge that the development of the knowledge of data use for teaching is both an individual and collective endeavor. According to Datnow and Hubbard (2015), teachers’ capacity to use data and their beliefs about data use are shaped within their professional communities, in training sessions, and in their interactions with coaches, consultants, and principals. Unfortunately, while collaboration can support individual teacher efforts in responding to data, teacher teams with limited expertise can misinterpret or misuse data.
As teachers proceed through data-driven decision making, they engage in sensemaking. Sensemaking is the process by which individuals and groups make meaning of new experiences and ideas, particularly during times of ambiguity or uncertainty (Farrell & Marsh, 2016). This theory sheds light on the way teachers respond to data in such varied ways and in ways that often do not align with the idealized version of data-driven decision making. Research on policy implementation indicates that teacher responses are primarily driven by teachers’ prior knowledge, beliefs, and values, which may lead to differences in implementation (Coburn, 2001, 2005; Spillane, Reiser, & Reimer, 2002). With this in mind, mixed results about teachers’ responses to data may be explained by sensemaking (Marsh, 2012). Within sensemaking, there are two different constructs that impact how teachers ultimately respond to data. The constructs include the data cycle and attribution theory.

The data cycle includes four phases along a continuum, beginning with teachers accessing (a) data. They then analyze the data to turn it into (b) information and combine it with their understanding and expertise to generate actionable (c) knowledge, which can then be used to (d) respond to data. Current discourse, however, emphasizes that the first three phases on this continuum are central aspects of sensemaking. As such, it is possible that these are not phases, but, instead, mutually influential processes that do not necessarily fall along a single continuum (Bertrand & Marsh, 2015).

In the process of transforming data into actionable knowledge, teachers make decisions about the causes of student academic outcomes (Nelson et al., 2012; Ola’h et al., 2010; Schildkamp & Kuiper, 2010). These attributions—or perceived causes of outcomes (Seifert, 2004)—may, in turn, influence the process itself, a supposition supported by research describing teachers making generalizations about the causes of student outcomes (Schildkamp & Kuiper,
This suggests that sensemaking entails not only the transformation of data to knowledge but also attribution. Within the iterative sensemaking process, teachers may (re)form understandings of causes of student outcomes, which, in turn, affect how data may be transformed into knowledge and, ultimately, how the teacher responds to the data. How teachers attribute outcomes is especially important since this shapes their future instruction and expectations for students.

As teachers engage in sensemaking, mental models act as filters through which the data are understood. The application of these mental models may give rise to attributions, specifically, decisions about the locus of causality, stability, and controllability. Bertrand and Marsh (2015) describe four mental models of sensemaking, including instruction (model 1), student understanding (model 2), nature of the test (model 3), and student characteristics (model 4).

While data-driven decision instruction has been shown to improve student outcomes, only a small number of studies have articulated the types of instructional changes teachers make in response to their analysis of data (e.g., Blanc et al., 2010; Christman et al., 2009; Cosner, 2011; Davidson & Frohbieter, 2011; Datnow & Park, 2014; Farrell & Marsh, 2016; Hoover & Abrams, 2013; Nabors Olah et al., 2013; Pierce & Chick, 2011). Interestingly, these studies provide some information on the types of instructional adjustments teachers make but only from the teacher’s perspective. In a recent case study of five low-income, high-needs middle schools in three districts, Farrell and Marsh (2016) provide additional insights into the types of response teachers employ as a result of data-driven decision making. Specifically, they better define the four different types of instructional responses that emerged from the analysis of various data.
sources. These types of instructional changes included change in delivery, reteach and retest, small groups, and student analysis.

Although some studies point to the potential for data to substantively inform and shape teachers’ practice (Hamilton et al., 2009; Konstantopoulos, Miller, & van der Ploeg, 2013; Marsh, 2012; Nelson, Slavit, & Deuel, 2012), others indicate that teachers may not significantly alter their instruction in response to data (Ikemoto & Marsh, 2007; Ola’h, Lawrence, & Riggan, 2010). This may be due in large part to the type of assessment teachers examine during the data-driven decision-making process. In a 2016 study, Farrell and Marsh examined how teachers responded to data generated from four different assessment types, including state assessments, district benchmark assessments, common grade-level assessments, classroom assessment data, and student work. Interestingly, teachers responded in varied ways depending on the assessment type. Still, an in-depth review of the literature revealed that there is a lack of description of how teachers respond specifically to data obtained from universal screeners.

In summary, current research dictates the need for a better understanding of two critical concepts within data-driven decision making. First, the educational community could benefit from a more in-depth analysis of how mental models of sensemaking are applied to data obtained for a universal screener. Finally, a more robust description of how teachers respond to this data that goes beyond self-disclosure is needed. By addressing both of these concepts in my study, I can support schools and districts to better obtain the desired outcomes of data-driven decision making.

**Literature Deficiency Statement**

Different forms of data invoke a variety of instructional responses (Farrell & Marsh, 2016). However, there is a paucity of research on the influence of the nature of the data, the type,
and the way it is derived on teachers’ sensemaking (Bertrand & Marsh, 2015). In response to this lack of information, Farrell and Marsh (2016) examined student achievement data from the following sources: state assessments, district benchmarks, common grade-level assessments, classroom assessment, and student work. The authors found that the closer the practitioner was to the assessments, the more likely changes in instructional practices would occur. For example, state assessments, which educators have little control over, were shown to have little impact on instruction. Classroom assessments and student work, on the other hand, were proportionately linked to changes in instructional delivery.

While Marsh and Farrell (2016) shed some light on how data types, such as state assessments and district benchmark assessments, impact instructional change, there is a need to gain further insight into this phenomenon. Additional clarification is needed to determine not only the types of mental models that are applied when utilizing data obtained from universal screeners, but also the types of instructional responses. Universal screeners differ from state assessments, district benchmarks, and common grade-level assessments in that their purpose is to predict or identify students who may be at risk for not achieving the intended learning outcomes (Center on Response to Intervention). Universal screeners are typically brief and conducted with all students at a grade level with the purpose of identifying at-risk students. After screeners are administered, a school system can employ Response to Intervention (RTI), a tiered process of instruction that allows for the identification of struggling students and the appropriate application of instructional interventions (Bruce, 2016).

One such screener that is gaining popularity throughout the Midwest is the Delta Math RtI Program. Delta Math is an RtI program that provides online grade-level readiness screening and standards-based reporting, paper-based progress monitoring, and Tier 2 instructional support
for Kindergarten through Algebra 1. Delta Math is unique amongst other mathematics screeners for a variety of reasons. First, many screeners do not give grade level specific information, instead teachers may only be given information on a grade level band, like K-1. Additionally, many mathematics screeners can only be utilized for students in grades K-3 and are not applicable for students in grades 4-12. Finally, most screeners only provide an overall score that only indicates student proficiency. Delta Math on the other hand provides data reports that give teachers specific insights into how students are performing on specific grade level readiness standards (Klavon, 2019).

Knowing that mental models promote positive instructional change, specifically the models of instruction and student understanding, it would be beneficial to study how teachers interact with this particular data source to determine whether or not these models are applied. In doing so, it might support instructional leaders in prioritizing Delta Math amongst the myriad of assessment options.

**Significance of Study**

This study is significant in three specific ways. First, the existing conceptual frameworks that capture the process of data-driven decision making, specifically those presented by Bertrand and Marsh (2015), which was adopted from Mandinach, Honey, Light, and Brunner (2008) and Marsh, Pane, and Hamilton (2006), do not incorporate mental models within the process of sensemaking. While Bertrand and Marsh (2015) discuss the role of mental models within sensemaking, these models are treated as a separate component instead of a means to better describe attribution within the process of sensemaking. Additionally, this study provides insight into how teachers make sense of data and apply mental models to data from a universal screener. Previous research has focused on how teachers apply mental models to data obtained from state,
benchmark, common, and classroom assessments (Bertrand & Marsh, 2015; Farrell & Marsh, 2016). However, my review of the literature reveals no studies that address the application of mental models to Delta Math screeners. Finally, this study is significant because it will provide a richer description of the types of instructional change that result from teachers engaging in data-driven decision making. To date, only a small number of studies have articulated the types of instructional changes teachers make in response to their analysis of data (e.g., Blanc et al., 2010; Christman et al., 2009; Cosner, 2011; Davidson & Frohbieter, 2011; Datnow & Park, 2014; Farrell & Marsh, 2016; Hoover & Abrams, 2013; Nabors Olah et al., 2013; Pierce & Chick, 2011). Interestingly, these studies provide some information on the types of instructional adjustments teachers make but only from the teacher’s perspective.

**Purpose Statement & Research Questions**

The purpose of this multiple-case study is to describe and interpret how elementary teachers in grades 1-5 engage in sensemaking of data obtained from the Delta Math Readiness Screener. Using a modified theoretical framework established by Bertrand and Marsh (2015) that employs four distinct lenses, namely a reconceptualization of the data cycle, sensemaking, attribution theory, and mental models, I intend to capture the mental models that are applied as teachers engage in the data cycle. Additionally, this study will investigate the types of instructional changes that are employed by teachers as a result of these mental models.

**Research Questions**

The gaps articulated in the aforementioned discussion will provide answers to the following questions:

1. What types of mental models are applied during sensemaking within the Delta Math RtI Program data cycle?
2. How do these mental models change over the course of the school year?

3. What types of instructional change result from these mental models?

**Conceptual Framework and Narrative**

This study is deeply influenced by the research conducted by Bertrand and Marsh (2015) as they describe three distinct lenses that capture the cognitive processes involved in teachers’ attributions of data. These lenses include a reconceptualization of the data cycle, attribution theory, and sensemaking theory. *Figure 1* provides a brief recapitulation of the theoretical frame that will help guide this study.

*Figure 1*. The data cycle

As the above figure illustrates, data-driven decision making is a nonlinear dynamic process that is shaped by beliefs and past experiences. Within DDDM, sensemaking is a recursive process that is impacted by attributions or reasons for outcomes. Ultimately, this iterative relationship impacts possible responses to data and its corresponding use (Bertrand & Marsh, 2016).

**The Data Use Cycle**

The data use cycle that Bertrand and Marsh (2015) describe in the framework originated from the DDDM framework created by Mandinach, Honey, Light, and Brunner (2008). In this
framework, teachers cycle through four phases: data, information, knowledge, and response to data (See Figure 2 below).

**Figure 2. Framework for data-driven decision making**

As Light and colleagues (2004) note: Data exist in a raw state. Data do not have meaning in and of itself, and, therefore, can exist in any form, usable or not. Information is data that is given meaning when connected to a context. Knowledge is the collection of information deemed useful and eventually used to guide action. The above description provides a logical progression, which demonstrates the progression of raw data to usable knowledge. This knowledge then leads to a decision on the part of the practitioner. While Mandinach et al. (2008) advocate for a linear progression of decision making, more recent dialogue reveals that this process is far more complex and may not follow a linear model (Coburn & Turner, 2011; Datnow et al., 2012; Farley-Ripple & Buttram, 2014; Salvit, Nelson, & Deuel, 2013).

**Attribution Theory**

In transforming data into actionable knowledge, teachers may make decisions about the causes of student academic outcomes (Nelson et al., 2012; Oláh et al., 2010; Schildkamp &
Kuiper, 2010). These attributions, or perceived causes of outcomes (Seifert, 2004), may, in turn, influence the data analysis process itself. This suggests that sensemaking involves the transformation of data into knowledge and that this process is influenced by the attributions of individuals. That is, within the iterative sensemaking process, teachers may form understandings of causes of student outcomes, which, in turn, affect how data may be transformed into knowledge.

Attribution theory identifies three characteristics of attributions that articulate the relationship between individuals’ motivation to act and their perceptions of causes of outcomes (Seifert, 2004; Weiner, 2010). First, there is the locus of causality, ranging from internal (one’s self) to external (someone or something else). The second characteristic is stability, which refers to a person’s assessment of whether a cause is enduring or transitory. The final characteristic is controllability, or an individual’s belief in her ability to control an outcome. How an individual formulates attributions has behavioral consequences (Seifert, 2004; Weiner, 2010), including motivation for future achievement, persistence in a task, and intensity in tackling a task (Dweck & Leggett, 1988; Nicholls, 1984).

Attribution theory, therefore, provides insights into the process by which teachers assign causes to data and the potential influence these assignments have on motivation to take action in response to the data. For instance, if a teacher had attributed the poor student outcomes to her students (external locus of causality), considering them to be “slow learners” (a stable characteristic out of her control), the theory predicts low motivation to improve instruction.

Sensemaking

The concept of sensemaking (Weick, 1995; Weick, Sutcliffe, & Obstfeld, 2005) helps explain why attribution and data analysis may unfold in specific ways and how these phenomena
may influence responses. The literature indicates that data analysis occurs within larger sensemaking processes (Datnow et al., 2012; Slavit et al., 2013; Spillane, 2012; Spillane & Miele, 2007). According to sensemaking theory, people partially construct their reality by creating meanings for their experiences (Coburn, 2001; Spillane & Miele, 2007; Spillane et al., 2002; Weick, 1995). Throughout this process, mental models arise, affecting how people make sense experiences. Mental models are defined to be people’s beliefs about causal relationships. These models reflect implicit understandings that can be inferred but not directly observed, and teachers may unknowingly use more than one model at a time (Spillane & Miele, 2007; S. Strauss, 1993).

**Mental Models**

Bertrand and Marsh (2015) suggest that during DDDM, teachers activate a variety of mental models of sensemaking when attributing student-outcome data. Mental models are comprised of assumptions, definitions, and beliefs around a concept and that subsequent actions proceed from these models (Johnson-Laird, 1986; Senge, 2006). Mental models are not static and can be reshaped when members of an organization are open to knowledge sharing. Findings suggest that educators approached data use from a range of mental models, some more positive than others. This is significant in light of emerging research, which suggests that educators respond more constructively to data when they associate it with classroom-based improvement efforts rather than accountability or compliance efforts (Daly, 2009; Jimerson & McGhee, 2013; Tucker, 2010).

Mental models for data use are always “under construction” as new stimuli, experiences, and knowledge are introduced into educators’ frames of reference, mental models evolve. Additionally, the forces that shape and reshape mental models involve personal prior experience,
formal training, social interaction with colleagues, and leader modeling. These influences can enrich or restrict ways of thinking about data use. Finally, the ways in which educators use data may be influenced by their mental models. Thus, one role of school leaders is to help educators develop ways of considering data use that are sufficiently broad to allow teachers to respond in a variety of ways (Jimmerson, 2014).

Bertrand and Marsh (2015) describe four distinct mental models that arise during sensemaking including instruction, student understanding, student characteristics, and the nature of the test. The reader is referred to Table 3.

Table 1

The Four Mental Models of Sensemaking

<table>
<thead>
<tr>
<th>Locus of causality</th>
<th>Attribution to . . .</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal</td>
<td>Instruction</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>External</td>
<td>Student Understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal or external</td>
<td>Nature of Test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External</td>
<td>Student Characteristics</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Stability</td>
<td>Instability</td>
<td></td>
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<td>Instability</td>
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<td>Controllability</td>
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<td>Controllability</td>
<td>Controllability</td>
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<tr>
<td>Controllability or uncontrolability</td>
<td>Controllability or uncontrolability</td>
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</tbody>
</table>

*Depends on whether the teacher has a role in test creation.

Encompassing beliefs about the causes of student outcomes, the models have implications for teacher motivation to change instruction. Interestingly, when teachers utilize the instruction model, they believe that classroom instruction influences student learning, which is reflected in the data. Furthermore, the instruction model is normative and has the potential to motivate teachers to improve their instruction.
The student understanding model is realized when teachers cite student understanding as the cause of student learning results. Like the instruction model, this approach to data is normative and is cited as beneficial to instruction in the research literature (Goertz, Oláh, & Riggan, 2009; Supovitz, 2012). The nature of the test model, on the other hand, assumes that the nature of the test affects student outcomes. However, this model does not appear to provide an impetus to improve instruction. In the final model, student characteristics, the perceived cause of student outcomes, are inherent student characteristics. These characteristics could include low socio-economic status, emotional or cognitive impairments. Often these characteristics are specific to certain groups rather than all students. Attribution to student characteristics could undermine motivation to adjust instruction because it involves an external locus of causality, stability, and uncontrollability.

Data use is an act of sensemaking (Datnow et al., 2012; Spillane, 2012; Spillane & Miele, 2007) that is influenced by teachers’ past experiences and beliefs. As teachers engage in sensemaking, mental models act as filters through which the data are understood. The application of these mental models may give rise to attributions, specifically decisions about the locus of causality, stability, and controllability. This allows teachers to link present outcomes to past phenomena, such as student characteristics. In combining sensemaking theory with attribution theory and the reconceptualized data cycle, I am able to capture how teachers come to understand data, which, in turn, will impact their willingness to change instructional practice.

Building on these theories, my conceptual framework helps to explain the role mental models play in determining attributions, reasons for outcomes, and better articulating possible responses to data. Attributions arise as teachers make decisions about the locus of causality,
stability, and controllability. These decisions are based on the mental models, that is the beliefs, attitudes, knowledge and feelings of the teachers. A specific set of decisions characterizes a mental model that gives rise to a particular attribution. For example, if a teacher decides that the locus of control is internal, the outcome is not stable and controllable, then they will attribute the outcome to their instruction. If this attribution is applied, then the teacher’s response will be to change their instructional practice in order to improve student outcomes. If, on the other hand, a teacher decides that the locus of control is external, the outcome is not stable but controllable, then they will attribute the outcome to student understanding. If this is the case, then again the teacher will respond by changing their instruction.

Next, if a teacher decides that the locus of control is external, the outcome is stable but not controllable, then they will attribute the outcome to student characteristics. Unfortunately, if this series of decisions is made, then a teacher is not likely to change their instruction in order to improve student outcomes. The final mental model, Nature of the Test, can be applied in two different ways depending on whether or not the teacher has a role in creating the test. If the teacher does not have a role in creating the test, then the locus of control will be external, and the outcome will be uncontrollably stable. In this case, a teacher is not likely to change their instruction. If, on the other hand, the teacher has a role in creating the assessment, then the locus of control will be internal and the outcome unstable but within the control of teacher. Interestingly, while this case will likely yield a change response, it will not be a change in instruction. Instead, a teacher who applies this particular version of the mental model will only change aspects of test. (See Figure 3 Below.)
Figure 3. Conceptual framework for data-driven decision making (Bingham, 2017)
The above diagram illustrates the conceptual framework that I will employ for this study. It is important to note that this framework incorporates mental models within the construct of attributions. Previous research has investigated the sensemaking and mental models separately. However, by including mental models, I have better defined the nature of attributions and the potential responses of teachers. In considering the progression of conceptual frameworks that capture data-driven decision making, my framework builds upon the foundation that was first laid by Mandinach, Honey, Light, and Brunner (2008). Mandinach, Honey, Light, and Brunner (2008) illustrate a linear process whereby the data-to-knowledge continuum is defined by the inclusion of six cognitive skills or actions that are crucial to the decision-making process. Bertrand and Marsh (2015) then revealed that while teachers engage in a cycle where data is transformed to information, knowledge and then possibly action, this process is not linear and is embedded within sensemaking. Furthermore, within this process teachers apply various mental models that impact whether or not their response will result in a change of practice. Ultimately, my framework elevates the work of my predecessors to include mental models within the construct of sensemaking. Additionally, it adds to existing scholarly work by providing greater detail regarding the types of response teachers will employ as a result of the mental model that is applied.

**Methods Overview**

The qualitative approach that I will utilize is a multiple-case study. According to Merriam (1998), a case study is a holistic description of a bounded phenomenon, such as a program, an institution, a person, a process, or a social unit” (p. 8). The bounded system this study will investigate is: the process of sensemaking of data obtained from the Delta Math readiness screener and the resulting changes in instruction employed by first-fifth grade
educators. Yin (2018) claims that case study methodology is appropriate if the following are true: the main research question is “how” or “why”, there is little or no control over the behavioral events, and the focus of a study is on a contemporary phenomenon investigated within a real-world context. Given that I have no control over this contemporary phenomenon and the research questions attend how teachers make sense of data, case study is the best way to conduct research on this topic.

My approach to case study methodology is aligned with constructionism. Unlike the positivist view that real truth is out there, constructionists believe that truth and reality are not discovered but are reconstructed by people within their everyday contexts (Charmaz, 2008; MacDonald and Schreiber, 2001). Constructionism is rooted in context and maintains that different versions of truth are valid (Duncan et al., 2007; White, 2004). Because I am interested in how teachers make sense of and respond to data, having this type of orientation will be essential to understanding and describing the phenomenon under review. As such, I will seek to capture the various realities of the participants by working collaboratively with them. This, in turn, will enable me to bring clarity to the beliefs and actions of the participants (Baxter & Jack, 2008).

Data collection for this case study will draw from multiple resources, including observations and semi-structured interviews. Through data collection, a detailed description of the case will emerge (Creswell, 2014). An analysis of themes will then be conducted to identify key issues embedded in the description.
Chapter 1 Closure

In conclusion, this study explores how teachers apply mental models as they make sense of data obtained from Delta Math, a universal screener that supports the identification of students at risk in mathematics. While previous studies have studied the application of mental models to other types of assessments, this study will investigate this application to a screener, utilizing a framework that embeds mental models within the sensemaking process. Finally, this study enriches scholarly dialogue by providing a description of the types of instructional changes that result from the application of these mental models.
CHAPTER II
LITERATURE REVIEW

This qualitative study explores how teachers apply mental models as they make sense of data obtained from a universal screener. This study enriches scholarly dialogue by providing additional insight into both the application of mental models to a specific data source and a description of the resulting changes to instruction. The purpose of this multiple case study is to describe and interpret how mathematics teachers in grades 1-5 make sense of data from Delta Math within a collaborative context. Additionally, this study will capture the types of changes, if any, that teachers make as a result of analyzing this particular data source.

The literature review is divided into sections: (a) data-driven decision-making defined; (b) key strategies for performance driven schools; and (c) the role of the teacher within data-driven decision making. The purpose of this literature review is to articulate what is currently known about data-driven decision making and to establish what is currently missing from this conversation. In doing so, this chapter will provide the rationale for this study.

Data-Driven Decision Making: Definitions, Policy, and Effects

Data-Driven Decision Making Defined

Data-driven decision making (DDDM) is a complex process in which data are systematically collected, analyzed, examined, and interpreted in order to inform practice and policy within schools (Mandinach, 2012). As both teachers and administrators engage in this process, the underlying belief is that utilizing data to make a variety of decisions will improve a child’s access to quality instruction and, ultimately, student achievement. In order to capture the various components of this intricate process, a description of a conceptual framework is necessary. Over the past decade, several DDDM frameworks have emerged (Abbott, 2008;
Easton 2009; Hamilton et al., 2009; Ikemoto & Marsh, 2007; Mandinach et al., 2008; Means et al., 2010). However, the framework presented by Mandinach and colleagues (2008) best articulates the cognitive skills that are hypothesized to be involved in DDDM (Mandinach, 2012).

Figure 4. Conceptual framework for data-driven decision making

Careful analysis of Figure 4 above reveals the six skills necessary to engage in DDDM. These skills include collecting, organizing, analyzing, summarizing, synthesizing, and prioritizing data. As teachers utilize each of these skills, notice how the data, which are simply numbers with no meaning, are transformed into information and then knowledge. It is this knowledge that will be used to make a decision that will be implemented. The impact of the decision will then be measured. Then, based on the results, the data user will once again engage in the process, making appropriate adjustments along the way. Note that DDDM is an iterative process that is not linear in nature.

In order to better understand the six skills embedded in DDDM, consider the following scenario. Using a variety of sources including classroom observations, student work samples, along with local and state results, a teacher begins to collect data on their students’
understanding of multi-digit multiplication. The teacher then organizes the results in a manner that allows them to efficiently analyze the results. In doing so, they begin to examine areas of strength and weakness and identify points of understanding and misconception. The teacher will then extract information from the analysis and summarize key findings. Educators may note that certain groups of students exhibited a particular misconception because they lacked a conceptual understanding of multiplication. The teacher will then synthesize the results, which will create a knowledge base of possible next steps. They will then prioritize these next steps in order to address the needs of students. For example, during intervention time the teacher may decide to work with a small group of students who exhibited the same misconceptions around multiplication. Finally, the teacher will implement the decision and examine its impact. Based on the results, the teacher may need to collect more data, perform additional analyses, or investigate another instructional strategy. For example, in working with the small group of students, the teacher may discover that their lack of conceptual understanding is linked to limited exposure to concrete manipulatives.

Not only does the framework illustrate the six skills of data users, it reveals that data are seen as hierarchical in structure (Mandinach, 2012). There are classroom-level, school-level, and district-level data, and this data typically flows from the classroom upwards. Data then flow from the district to the state and federal level, creating what Smith (2009) calls the “data highway”. Interestingly, the same data may be interpreted in many different ways along the highway (Mandinach & Smith, 2011). Sensemaking depends on the purpose for which the data are being collected and examined, as well as the role of the user.

Regardless of the type of data, DDDM is seen as a cyclical or iterative process of identifying a problem, determining possible solutions, and monitoring the implementation of the
solution. This generic model for DDDM describes a process that can be used by both teachers and administrators to make a variety of decisions within an educational context.

**The Role of Federal Policy**

Now that data-driven decision making has been defined, I will focus on how this practice came to be a foundational component of educational policy. Interestingly, data-driven decision making originated from successful practices in industry, specifically, Total Quality Management, Organizational Learning and Continuous Improvement. Each of these practices contend that “organizational improvement is enhanced by responsiveness to various types of data” (RAND, 2006). While DDDM in education is a relatively new practice, it can be traced back to the 1970’s and 1980’s when states required schools to use outcome data in school improvement planning and site-based decision making (Massell, 2001). Still, I contend that effective teachers have always engaged in DDDM. The practice of observing students and making decisions based off of informal observations coincide with many of the core components of DDDM. However, this practice was not necessarily systematic and relied heavily on teacher intuition (Jacobs et al., 2009).

Ultimately, though, it was the No Child Left Behind Act (NCLB) of 2002 that thrust DDDM into the spotlight. This monumental piece of federal legislation presented new opportunities and incentives for data use in education by providing schools and districts with additional data for analysis (Massell, 2001). Essentially, NCLB mandated increased attention on multiple sources of data that could measure student learning and ultimately hold districts accountable for achievement of adequate yearly progress (AYP). As a result, school administrators were now responsible for monitoring and supporting improvement for both
student and teacher. In order to monitor this performance, it was essential that the school leader have access to a sophisticated system for data collection and analysis.

However, as districts began to implement the mandates of No Child Left Behind, they found that not only did they not have the technological infrastructure to efficiently gather, organize and analyze data, they lacked data literacy. According to Mandinach (2012), two key components of Data-Driven Decision Making are access to technological tools to support the data inquiry process and data literacy. Moreover, even if teachers have access to high-quality technological solutions, without data literacy, the benefits of this technology cannot be realized. While there is still much debate around what it means for an individual to be data literate, Mandinach and Gummer (2016) provide the following definition:

Data literacy for teaching is the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting all types of types of data (assessment, school, climate, behavioral, snapshot, longitudinal, moment-to-moment, etc.) to help determine instructional steps. It combines an understanding of data with standards, disciplinary knowledge and practices, curricular knowledge, pedagogical content knowledge and an understanding of how children learn. (p. 2)

Interestingly, as these federal mandates began to make their way into classrooms across the nation, it became readily apparent that these DDDM components were not in place. Unfortunately, teachers and administrators rarely receive the high-quality professional development necessary for them to become data literate (Mandinach & Gummer, 2010). In fact, a recent survey found that only 19 states required the ability to evaluate the accuracy of a data set and transform the data into action as a requirement for teacher licensure (Dyer, 2014).
Furthermore, the average data-management system is often composed of numerous spreadsheets, databases, and paper reports that are loosely connected through various interfaces. This lack of technological coherence renders it difficult for the user to retrieve and analyze data in an efficient manner (Messelt, 2004). According to a 2010 report from the Department of Education, 60% of schools noted that their current data-management systems actually limited their ability to expand the use of data in the classroom. Additionally, a 2014 survey of 4,600 teachers by the Bill and Melinda Gates Foundation found that while many teachers believed they could utilize data to improve their practice, only 33% of teachers believed they possessed the technological tools to utilize data in an efficient manner.

In response to the challenges surrounding the successful implementation of data-driven decision making mandated by No Child Left Behind, the American Recovery and Reinvestment Act of 2009, along with the Race to the Top Competition sponsored by the US Department of Education, provided incentives to states to build improved data systems to measure student progress. Furthermore, the incentives provided opportunities for teachers to improve their practices around DDDM. Additionally, the government set aside $350 million to fund the development of better state assessments (Datnow, Park & Lewis, 2012). The rationale for the improvement of state assessments may stem from a 2006 study conducted by Kerr et al., which found that many educators perceived state assessment data to be out of date or irrelevant to their professional responsibilities. As a result, many educators disregarded the data obtained from these assessments. Still, the majority of studies contend that teachers utilize state assessment data out of compliance for school or district directives (Dembrosky et al., 2005; Gallagher et al., 2008; Hamilton et al., 2005).
As mandates surrounding data-driven decision making manifested themselves into activities of compliance rather than endeavors to improve teaching and learning, policy makers realized that a philosophical shift was needed. Specifically, schools needed to stop focusing on achieving adequate yearly process and instead utilize data to stimulate and inform continuous improvement. This, in turn, would provide a foundation for educators to examine multiple sources of data and align appropriate instructional strategies with the needs of individual students. No longer would data be used to hold educators and schools accountable (Mandinach, 2012). In order to promote this shift in practice and once again renew the focus on DDDM, the federal government passed the Every Student Succeeds Act (ESSA) of 2015.

The Every Student Succeeds Act (ESSA) supports teachers in truly integrating data into their practice, unlike its predecessor No Child Left Behind, which invoked compliance and accountability. ESSA propels education closer toward becoming an evidence-based and data-driven profession that research claims will improve student achievement. Furthermore, the new legislation specifically addresses the need to improve data literacy amongst educators. The law explicitly states that policy makers and administrators must “facilitate data-based instructional decision making” (p. 294) and provide professional learning opportunities for educators to learn how to use data responsibly. Furthermore, states must provide “instruction in the use of data and assessments to inform and instruct classroom practice” (p. 296). The expectation of ESSA is that teachers skilled in data will develop more effective classroom and instructional practices, which will ultimately lead to improved student achievement.

In summary, over the past few decades, policymakers have looked to data-driven decision making as a potential solution to some of education’s most difficult problems, including low student achievement in reading and math, improving graduation rates, and better preparing
students for college. Through various pieces of legislation like the No Child Left Behind Act of 2002, the American Recovery and Reinvestment Act of 2009, and the Every Student Succeeds Act of 2015, the federal government has attempted to provide the supports necessary for the successful implementation of DDDM. Still, what does research have to say about the effectiveness of DDDM? How have schools gone about implementing this practice and what impact is it having on student achievement?

**The Effectiveness of Data-Driven Decision Making**

Not only has legislation dictated its necessity, decades of research support that the use of student data is positively correlated with a variety of school factors including improved professional collaboration, more varied instructional practices, and increased student achievement. For example, in a survey of 32 K-8 schools in San Francisco Bay Area, Symonds (2004) found that gap-closing schools, i.e. schools where all students made improvements but low-performing students made more rapid progress, had greater teacher support for data use. Specifically, teachers in gap-closing schools were more likely to use data to understand skill gaps of low-achieving students and receive professional development on how to analyze data. Additionally, they sought out support on how to link appropriate instructional strategies to low-performing student data.

In another large-scale survey of California elementary schools serving low-income students, Williams, Kirst, Haertel et al. (2005) found that using data to improve student achievement and instruction was one of the four critical school reform practices associated with high performance. The study surveyed approximately 5,500 teachers and 257 principals across the state and determined that data-driven decision making was strongly correlated with a higher academic performance index (API). Principals and teachers from these high-performing districts
reported that they utilized both CST and CAT/6 data to examine school-wide instructional issues and to develop strategies for moving students from below basic and basic to proficient.

Wayman and Stringfield (2006), on the other hand, identified three exemplary schools in the United States that were dedicated to involving all teachers in utilizing their data systems to examine student progress and inform instruction. Their study found that data use often resulted in improved teaching practices, such as increased professional collaboration and a better understanding of student needs. As a result, these teachers reported growth in their abilities to differentiate instruction for their learners.

Moreover, in a mixed methods study of a statewide reading coach program, Marsh et al. (2010) found that 75% of reading teachers and 72% of social studies teachers who had received data support from a coach reported changes in their instruction. Examples of these changes included working to connect the readings to students’ existing knowledge and lives more often and allowing students to select more of what they read. Additionally, the data from this study suggested that frequent data support from a coach is associated with higher student achievement (albeit small in magnitude).

Finally, Carlson, Borman and Robinson (2011) found significant increases in mathematics achievement along with notable increases in reading achievement after a year of data-driven reform guided by the Johns Hopkins Center for Data-Driven Reform in Education when compared to a control group that had not experienced any data-reform training. “Quite simply, high-performing districts make decisions based on data, not on instinct” (Supovitz & Taylor, 2003; Togneri, 2003).

While there are several examples of the positive effects of data-driven decision making, Marsh et al. (2006) contend that most of the research on this topic has examined the
implementation of DDDM. As a result, a set of factors that are associated with more effective use of data by educators has been identified. Notably, several studies have identified the importance of providing professional development around the appropriate use of data (Black & William, 1998; Datnow, Park, and Wohlstetter; 2007; Mason, 2002; Supovitz & Klein, 2003). Such professional development provides opportunities for educators to address such skills as interpreting results and employing effective instructional strategies to address specific student learning outcomes identified in the data. In the next section, I will address these implementation factors utilizing the Key Performance Strategies of Performance Driven School Districts (Datnow, Park, & Wohlstetter; 2007). These strategies include building a foundation of DDDM, culture of data use, information management systems, selecting the right data, building school capacity, analyzing and acting on data, and, finally, barriers to Data-Driven Decision Making. Through the investigation of these strategies, I will paint the current landscape of best practice in regards to the implementation of DDDM in schools.

**Key Strategies of Performance Driven School Systems**

The theory of action underlying NCLB requires that educators know how to analyze, interpret, and use data so that they can make informed decisions. Data need to be actively used, at all levels, to improve instruction in schools; however, schools often lack the capacity to successfully implement research (Diamond & Spillane, 2004; Ingram et al., 2004; Mason, 2000; Petrides & Nodine, 2005; Wohlstetter, Van Kirk, Robertson, & Mohrman, 1997). Still, district-level leadership can support schools in acquiring the skills and capacities necessary to engage in data-driven decision making. Specifically, districts that attend to the following strategies — building a foundation for data-driven decision making, establishing a culture of data use and continuous improvement, investing in an information management system, selecting the right
data, building school capacity for data-driven decision making, and analyzing and acting on data to improve performance — can support performance-driven school systems. It is these types of systems that can ultimately provide the conditions necessary to foster data-driven decision making.

**Building a Foundation for Data-Driven Decision Making**

In order for an educational organization to provide the conditions necessary to promote DDDM, it must first create a foundation that is rooted in developing a system-wide curriculum that is aligned to standards and is supported by high-quality materials (Datnow, Park, & Wohlstetter, 2007). DeFour (2016) refers to this as a guaranteed and viable curriculum. A guaranteed and viable curriculum ensures that all students have access to the same knowledge and skills regardless of teacher. Additionally, the content that teachers are required to address can be covered in the time available (Marzano, 2016). With this in mind, it is important that the curriculum is accompanied by a pacing plan that allows for some instructional flexibility based on the needs of the learners.

Not only is a guaranteed and viable curriculum necessary in building a strong foundation for DDDM, so, too, is setting specific and measurable goals around student achievement. Goals must be both explicit and targeted and developed at the district, school, and classroom levels (Datnow, Park & Wohlstetter, 2007). Furthermore, setting up goals empowers all stakeholders within the educational organization to reflect on their history, their current progress, and future plans. Without tangible student achievement goals, school systems are unable to orient their use of data toward a particular end or desired outcome. Ultimately, goal setting provides a focus for data-driven decision making.
Culture of Data Use

Not only is creating a foundation for data use via goal setting and establishing a guaranteed and viable curriculum an essential strategy for performance-driven schools, so, too, is establishing a culture of data use. Building a culture that values the regular, consistent use of data is essential to supporting a performance-driven system. Without this culture, it is easy for educators to fall into making decisions based on instinct alone. The question now becomes, how does an educational organization go about creating this type of culture? Datnow, Park and Wohlstetter (2007) recommend four key components. First, it is critical that explicit expectations and norms are developed so as to ensure that data use is a non-negotiable. Next, district- and building-level leadership must demonstrate to all stakeholders that the utilization of data will improve student achievement. Schildkamp and Kuiper (2010) further advocate that school leaders who express a clear vision for data use and provide the supports and resources necessary have an increased buy-in from staff. Finally, there must be a shared accountability around data use so that everyone in the organization is responsible for results.

Information Management Systems

Another strategy that is critical in supporting a performance-driven system is the adoption of an informational management system. It is often said that schools are “data rich, but information poor.” This is due in large part because school districts are bombarded by data from a variety of sources including state assessments, interim assessments, attendance, discipline and demographic data. However, without a means to systematically organize this multitude of data, it is very difficult for educators to make sense of the data and, ultimately, to prioritize in ways that improve student achievement. With this in mind, Datnow, Park, and Wohlstetter (2007) recommend that districts adopt user-friendly assessment systems that provide timely results and
are able to grow with school and systems needs. Examples of these systems include Data Director, Edusoft, and Triad.

Still, simply having a system to organize the data is not sufficient to support DDDM within educational organizations. Again, Datnow, Park, and Wohlstetter (2007) advocate for districts to invest in personnel at both the district- and school-level to support teachers and administrators in disseminating and translating the data into valuable information. Furthermore, these individuals, sometimes known as data specialists, can make recommendations regarding which students need additional support with core content. For example, a third-grade team of teachers could utilize an online assessment system like Data Director to determine the extent to which their students were proficient with fractions. Upon the completion of the assessment, a data specialist could inform the third-grade team which specific students will need additional support in understanding fractions. Not only could the data specialist identify those students who need additional support but that person could also identify those students who are ready for enrichment, that is students who have mastered the content and are ready to investigate the topic in a more in-depth manner. DeFour (2016) reminds us that it imperative for a professional learning community (PLC) to attend to the needs of students who are not ready learn and those who are ready for more advanced endeavors.

Burt and Reeves (2006) further support the need for a district to invest in personnel to support the organization and analysis of data. Specifically, Burt and Reeves highlight the additional needs of the building principal. Because building principals are instrumental in shaping the process, norms, and behaviors of teaching and learning (Glickman, Gordon, & Ross-Gordon, 2004), they must play a role in empowering teachers to utilize data to change instruction. However, Burt and Reeves (2006) discovered that many principals are
uncomfortable with data analysis. As a result, many building principals do not possess the skills necessary to support their teachers, who often possess even less understanding and appreciation for using data to make instructional decisions. However, a district- or building-level data specialist could elevate a principal’s ability to interpret and analyze data. This, in turn, can empower the principal to confidently shape a building culture that is centered around DDDM.

**Selecting the Right Data**

Another factor that is critical in the development of a performance-driven system is the utilization of data from a variety of sources including student achievement data, instructional practice data, and goal implementation data (Datnow, Park & Wohlstetter, 2007). Student achievement data can be characterized into two different categories, specifically, leading and trailing. Trailing data, that is data that is obtained from state assessments, are considered “older data” and do not empower teachers to change their instruction. However, it does give insight into the effectiveness of past instructional practices. Leading data, on the other hand, is data obtained from interim assessments that are administered more frequently. This type of data has the capability of informing more immediate instructional decisions. Interim assessments can be administered anywhere from three to six times per year and are aligned to standards. These assessments are often created locally, sometimes with the guidance of outside consultants. The data obtained from these assessments can support teachers in monitoring student learning throughout the school year.

Not only is student achievement data important in facilitating DDDM, so, too, is instructional practice data. This type of data can be obtained through the observations of classrooms by both teachers and administrators. Additionally, this data can provide insight into curriculum implementation, that is the degree to which educators are adhering to the district-
provided curriculum. In order to ensure that schools are able to utilize both instructional and student achievement data, it is important to provide time for teachers and administrators to engage in data-driven meetings. These types of collaborative opportunities can help contribute to a better understanding of a school’s progress toward student-achievement goals (Datnow, Park, & Wohlstetter, 2007). According to Heppen et al. (2010), teachers in urban districts who are provided concrete supports for data use, such as protected time for collaborative meetings and data specialists, are more likely to actually review interim assessment data and, in turn, to use the data to change their instruction. Additionally, teachers who spend more time reviewing data are more likely to adjust their instructional strategies and educational decision making in their classrooms.

**Building School Capacity**

A review of the literature indicates that building school capacity is yet another key component in developing a performance-driven system (Datnow, Park, & Wohlstetter, 2007; Farley & Buttram, 2015). It is important for district-level leadership to recognize that both building administrators and teachers have varying levels of comfort and expertise when engaging in DDDM. Therefore, investigating in professional development of data-informed instruction is necessary to build the capacity of all stakeholders. Professional development could occur in-house or a team of lead teachers could be sent to outside opportunities with the expectation of coming back and educating staff. Training could be facilitated around the adoption of a new data system or a new set of practices. It is also important to provide training for new staff at the beginning of each school year.

In order to ensure that professional development is continually leveraged after it has occurred, it is imperative that the district provide time for within-school collaboration that is
distinct from faculty and administrative business meetings. As teachers and administrators build
their own personal capacity to organize and interpret data, it is important for either a data
specialist or a data coach to support the facilitation of these collaborative data meetings.
Research has found that data use in schools is rarely an individual activity but rather this practice
is social in nature (Halverson et al., 2007; Means et al., 2009, 2011). Additionally, pre-existing
cognitive frameworks and beliefs influence how data are valued and interpreted. Therefore, how
data are interpreted and transformed into actionable information will depend on the individuals
involved. Research further suggests that effective data use stems from collaborative processes
(e.g., Datnow et al., 2007; Kerr et al., 2006; Lachat & Smith, 2005; Means et al., 2009;
Schildkamp & Kuiper, 2010; Wayman & Stringfield, 2006) and can result in better instructional
decision making (Lachat & Smith, 2005; Supovitz, Merrill, & Conger, 2010; Young, 2006). In
conclusion, DDDM is a collaborative process that is only as effective as the individuals involved.
Therefore, it is imperative that a district build the capacity of the individual through professional
development and provide protected blocks of time for collaboration.

**Analyzing and Acting on Data**

In addition to building capacity, it is important for district-level administrators to create
structured protocols that support teacher teams in having productive conversations around data.
For example, consider a fifth-grade English Language Arts team that recently administered an
interim assessment. To support this team in effectively engaging in their data, a district-created
template could guide the teachers to first discuss basic trends. The dialogue would then be
required to produce more detail regarding student strengths and weaknesses, grade-level trends,
along with ethnic, gender and language sub-group trends. The team would then be required to
brainstorm a variety of strategies and action plans for supporting both students who didn’t
perform well on the interim assessment and those who did (Datnow, Park, & Wohlstetter, 2007). In addition to this structure protocol, a district that supports DDDM would also support teacher teams in monitoring progress toward student achievement. Finally, not only is it important for teachers to monitor their progress toward goals, it is also important for districts to develop tools that engage students in data discussions and continuous improvement. This supports student achievement by engaging students in the process of DDDM and empowering them to own their own progress within various academic disciplines.

**The Role of the Teacher in DDDM**

**Teacher Beliefs and Capacity for Data Use**

Thus far, I have discussed the systems and conditions necessary to support DDDM in schools. I will now address the role of the teacher and teacher groups within this process. As previously mentioned, assessment data have the potential to inform how teachers plan lessons, identify concepts for reteaching, and differentiate instruction (Hamilton et al., 2009; Kerr, Marsh, Ikemoto, Darilek, and Barney, 2006; Supovitz, & Klein, 2003). Yet, how teachers actually use data to shape their decision making around their instructional practice is not entirely understood by the broader research community (Coburn & Turner, 2011; Little, 2012). In order for teachers to make sense of and use assessment data effectively, a range of knowledge and skills is necessary. Unfortunately, most studies have found that the majority of educators have had little professional development to support them in acquiring the skills and knowledge necessary to understand assessment data and to apply it within the context of instructional planning (Davidson & Frohbieter, 2011; Dunn, Airola, Lo, and Garrison, 2012; Kerr et al., 2006; Mandinach & Gummer, 2013; Shepard et al., 2011; U.S. Department of Education, 2010; Wayman & Cho, 2008). A national survey found that only 43% of teachers received some
training on how to analyze data from state and benchmark assessments. Interestingly, the majority of these educators did not find the training adequate enough to support their needs (Means, Padilla, Debarger, & Bakia, 2009).

Research has demonstrated that a lack of training will, in turn, limit a teacher’s capacity to use data effectively. However, as Farley-Ripple & Buttram (2015) explain, “there is little evidence on how capacity for data use develops.” (p. 2) Many districts attempt to implement effective data use by building data systems and helping teachers learn how to access data, rather than focusing on the skills teachers need to use data to inform instruction. Gummer and Mandinach (2015) refer to these particular skills as being data literate. In order for a teacher to be data literate, they must have the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting various types of data in order to determine instructional steps. Being data literate combines “an understanding of data with standards, disciplinary knowledge and practices, curricular knowledge, pedagogical content knowledge, and an understanding of how children learn” (Gummer & Mandinach, p. 2, 2015).

Absent sufficient training, teachers lack confidence in their ability to use data to improve instruction. Research indicates that teachers tend to be underprepared, anxious (Volante & Fazio, 2007 & Wayman, 2005), and lack confidence in their abilities to engage in DDDM (Bettesworth et al., 2008). In Pierce and Chick’s (2011) study, teachers felt handicapped in making sense of the data they were provided. Teachers found the reports difficult to understand, and they lacked confidence in dealing with statistical data. Dunn and colleagues (2012) surveyed over 1,700 teachers and found that teachers’ lack of efficacy in using data and their anxiety about the process limited their ability to use data effectively. Teachers’ sense of efficacy for DDDM reflects teachers’ beliefs in their ability to successfully complete the tasks associated
with DDDM in order to improve student outcomes (Airola, Dunn, & Garrison, 2011). DDDM anxiety is the trepidation, tension, and apprehension teachers feel related to their ability to successfully engage in DDDM (Airola et al., 2011). An important finding that emerged in this study was that teachers viewed the ability to analyze and interpret data as distinct from the ability to use the data to inform instructional practice.

Moreover, capacity-building efforts have focused primarily at the individual and organizational levels, rather than addressing how capacity is embedded in social relations. (Farley-Ripple & Buttram, 2015) Gummer and Mandinach (2015) acknowledge that the development of the knowledge of data use for teaching is both an individual and collective endeavor. According to Datnow and Hubbard (2015), teachers’ capacity to use data and their beliefs about data use are shaped within their professional communities, in training sessions, and in their interactions with coaches, consultants, and principals. Various studies also find that structures, such as grade-level agendas and cultural norms as well as the level of expertise in the group, all play into teacher collaboration around data use (Horn & Little 2010; Young 2006). Unfortunately, while collaboration can support individual teacher efforts in responding to data, teacher teams with limited expertise can misinterpret or misuse data. Additionally, it has been documented that teacher teams can actually work together to perpetuate poor classroom practice (Daly, 2012).

Still, efforts to develop teachers’ capacity for data use often fall short of their goals. Correspondingly, teachers have varied beliefs about data use, and some feel they lack the ability to use data to inform instruction. In order to be more successful, capacity building should directly address teachers’ beliefs, and data use must be decoupled from external accountability demands and involve a variety of information on student learning (Datnow & Hubbard, 2015).
Earl and Katz (2006) go on to explain that teachers need opportunities to develop and practice their skills at using data in order to help them move along a developmental continuum from novice users of data to ideally eventually becoming expert users of data.

While there are many lessons from the research reviewed here, this analysis also uncovered a lack of research on the intersection of teachers’ capacity building and beliefs about data use. More research is needed that is focused on efforts to build capacity in combination with deliberately attending to teachers’ beliefs, attitudes, and perceptions about data use (Datnow & Hubbard, 2015).

**How Teachers Make Sense of Data**

Sensemaking is the process by which individuals and groups make meaning of new experiences and ideas, particularly during times of ambiguity or uncertainty (Farrell & Marsh, 2016). Essentially, sensemaking describes how individuals make meaning of their experiences. This theory sheds light on the way teachers respond to data in such varied ways and in ways that often do not align with the idealized version of data-driven decision making. Research on policy implementation indicates that teacher responses are primarily driven by teachers’ prior knowledge, beliefs, and values, which may lead to differences in implementation (Coburn, 2001, 2005; Spillane, Reiser, & Reimer, 2002). With this in mind, mixed results about teachers’ responses to data may be explained by sensemaking, in addition to other reasons, such as variability in teacher supports (Marsh, 2012). Within sensemaking, there are two different constructs that impact how teachers ultimately respond to data. The constructs include the data cycle and attribution theory. The data cycle includes four phases along a continuum, beginning with teachers accessing (a) data. They then analyze the data to turn it into (b) information and combine it with their understanding and expertise to generate actionable (c) knowledge, which
can then be used to (d) respond to data. Current discourse in education emphasizes, however, that the first three elements on this continuum are central aspects of sensemaking and are not phases. Instead, they are possibly mutually influential processes that do not necessarily fall along a single continuum (Bertrand & Marsh, 2015).

In the process of transforming data into actionable knowledge, teachers make decisions about the causes of student academic outcomes (Nelson et al., 2012; Ola’h et al., 2010; Schildkamp & Kuiper, 2010). These attributions—or perceived causes of outcomes (Seifert, 2004)—may, in turn, influence the process itself, a supposition supported by research describing teachers making generalizations about the causes of student outcomes (Schildkamp & Kuiper, 2010). This suggests that sensemaking entails not only the transformation of data to knowledge but also attribution. Within the iterative sensemaking process, teachers may (re)form understandings of causes of student outcomes, which, in turn, affect how data may be transformed into knowledge and, ultimately, how the teacher responds to the data. How teachers attribute outcomes is especially important since this shapes their future instruction and expectations for students. For instance, teachers may attribute low test scores to prior instruction, as expected by data-use policies (Datnow, Park, & Kennedy-Lewis, 2012), or to perceived student deficits. Scholarship suggests that these different paths of attribution have implications for instruction and learning (Jussim & Harber, 2005; Schildkamp & Kuiper, 2010).

As previously mentioned in Chapter 1, data use is an act of sensemaking (Datnow et al., 2012; Spillane, 2012; Spillane & Miele, 2007) that is influenced by teachers’ past experiences and beliefs. As teachers engage in sensemaking, mental models act as filters through which the data are understood. The application of these mental models may give rise to attributions, specifically, decisions about the locus of causality, stability, and controllability. Bertrand and
Marsh (2015) describe four mental models of sensemaking, including instruction (Model 1), student understanding (Model 2), nature of the test (Model 3), and student characteristics (Model 4).

When considering Model 1, it becomes readily apparent that it is in alignment with the expectations of data-use policies. These policies articulate that teachers’ perception of a connection between teaching and outcomes allows for data to prompt instructional improvement (Mandinach, 2012). If a teacher applies this model during sensemaking, they might declare that ‘‘Classroom instruction influences student learning, which is reflected in data’’ (Bertrand & Marsh, p. 874, 2015). Teachers often drew on Model 1 when making sense of data in specific, concrete situations. For example, in Bertrand and Marsh’s (2015) study of six middle schools, this model was applied when a seventh-grade teacher described the results of a common grade assessment. Noting that one of her classes had more difficulty than another, she said:

What . . . [one class] had a hard time [with] was actually taking the story and analyzing it . . . , and I think that was because I maybe didn’t give them specific examples. With my other group, I think I went into more detail. . . . So maybe that’s . . . why my students did, one group did better than the other (p. 874).

By attributing the class’ difficulty with her previous instruction, the teacher demonstrated her application of Model 1. Furthermore, teachers who apply Model 1 attribute the outcome to an internal locus of causality. This is demonstrated by a teacher’s utilization of the word “I” during the sensemaking process. The utilization of this word indicates that the educator associates their actions with student misconceptions. Not only will the teacher see the locus of causality as internal, they will see their instruction as unstable. For example, a teacher might note that their instruction changed from class to class. Finally, a teacher who applies Model 1 will
acknowledge that they have control over student outcomes by describing how they might change the instruction. In summary, Model 1 has the potential to motivate teachers to improve their instruction. However, the teacher must be convinced of the following: (a) their instruction caused student outcomes, (b) their instruction is not always the same, and (c) they are in control of their instruction (Bertrand & Marsh, 2015).

Next, Model 2 involves teachers citing student understanding as the cause of student learning results (Bertrand & Marsh, 2015). A summation of this model could be: “Student understanding affects outcomes.” Similar to Model 1, this approach to data is beneficial to instruction (Goertz, Ola’h, & Riggan, 2009; Supovitz, 2012). Teachers usually invoked Model 2 to understand results for specific test questions. In Bertrand and Marsh’s 2015 study, a seventh-grade English language arts and social studies teacher employed this model to make sense of benchmark assessment results. Interestingly, his comments also indicate that he also applied Model 3 (involving attribution to test wording). Note that teachers can and do apply multiple mental models during the sensemaking process. Still, the following commentary specifically illustrates the application of Model 2. He explained:

[On the benchmark] there was stuff for the kids . . . that was hard reading. For me, personally, how they ask the questions, the words they used to ask questions, tend to be difficult. So I use that as kind of test-taking skills rather than just standards, kind of teaching them what it means, what they are asking you. . . . [A] lot of times the kids, they can read, and they know what they are reading, but they don’t understand what they [the questions] are asking of them. They don’t understand the question. So a lot of times, I’ll take those benchmark questions, and I’ll just put in the words if they can understand, kind of chart it up, so they’ll have it on the [wall in the] room, so they
In this explanation, the teacher sensemaking focused on student understanding when they took the benchmark assessment. As seen in the above quotation, Model 2 involves an external locus of causality. The cause of the benchmark results, was students’ understanding when they took the test. In Model 2, the cause—student understanding—was unstable. For instance, Mr. Johnson explained that “a lot of times” the students did not understand the test questions, suggesting that the misunderstanding occurred frequently but not all the time. In addition, he described instructional strategies he either planned to implement and/or had employed in the past to increase student understanding of the test questions, suggesting the attributional dimension of instability. Finally, Model 2 appeared to involve a belief that student understanding is controllable. Note that the teacher indicated that he could influence student understanding through instruction. In summary, Model 2 involves an external locus of causality, whereby outcomes are unstable and controllable. In other words, the teacher seems to believe that student understanding is changeable and controllable. According to attribution theory, teachers who utilize this model are more likely to alter instruction.

Model 3, on the other hand, predicts that “the nature of the test affects student outcomes” (Bertrand & Marsh, p. 877, 2015). As with Model 2, this model sometimes involved a focus on specific test questions instead of aggregate data. Interestingly, teachers often look at test scores and then analyzed the test itself to determine the validity of the questions. An example of Model 3 can be seen in the following quote from an eighth-grade English language arts teacher in response to a common assessment created by the professional learning community (PLC):

There was a question that 100 percent of the students got right, every single one. We looked at it... and we asked ourselves, ‘‘How was that useful? If everybody got it
right, was it a good question? I mean, could we have done, how can [we] tweak it so it would be framed in . . . such a way that it was too easy? (p. 851)

In this case, the teacher invokes an internal locus of control and suggests the attributional dimensions of instability and controllability. Interestingly, the implications for motivation related to Model 3 vary by context. When teachers are responsible for writing assessments, they may have understood test questions to reflect an internal locus of causality and be unstable and controllable. However, when teachers are not responsible for writing the test, they see the locus of causality as external and the outcomes as stable and uncontrollable. In either case, his model does not appear to provide a motive to improve instruction.

Finally, Model 4 can be explained as follows: “Students in this group have inherent abilities and attributes, which affect their learning and outcomes.” Often this model involved characterizing framing a particular student group having intractable difficulties with learning (Bertrand & Marsh, 2015). Additionally, this model encompassed attributions to students’ motivation or work ethic. Model 4 often involves a set of unspoken assumptions that allow causal relationships to make sense. In Bertrand and Marsh’s 2015 study, a seventh-grade English language arts teacher applied this model when explaining the low results of a benchmark exam:

It’s not surprising because I have some low boys in there, and I have some resource kids [students in special education]. So these two resource kids are below basic. I have some low kids in there, even the fact that there is [sic] only four below basic is good. The adjectives she used to connote struggling students were “low” and “below basic,” a designation corresponding to benchmark and state test scores. (p. 852)
Interestingly, this quote does not specify an area of difficulty but instead referred to students in special education as simply “below basic,” a description aimed at the students themselves, not their changeable traits. When a teacher applies Model 4, the locus of causality is external while the outcome is stable and uncontrollable. Unfortunately, attribution theory suggests that Model 4 could undermine motivation to adjust instruction. In addition, past research (Jussim & Harber, 2005) suggests that the use of Model 4—which involves low expectations—may have had implications for student outcomes. For example, a common belief among teachers is that higher-order thinking is not appropriate in the instruction of low-achieving students (Zohar, Degani, & Vaaknin, 2001). Such a belief may have several instructional consequences, as it limits the possible actions that teachers might take while planning their lessons. This could look like a seventh-grade teacher choosing to not explore linear relationships, for example, because students are unable to graph. This, in turn, becomes an equity issue as the teacher has made the instructional decision not to give students access to grade-level content because of their perceived abilities.

How Teachers Respond to Data

Response by type of instructional change

While data driven-decision instruction has been shown to improve student outcomes, only a small number of studies have articulated the types of instructional changes teachers make in response to their analysis of data (e.g., Blanc et al., 2010; Christman et al., 2009; Cosner, 2011; Davidson & Frohbieter, 2011; Datnow & Park, 2014; Farrell & Marsh, 2016; Hoover & Abrams, 2013; Nabors Olah et al., 2013; Pierce & Chick, 2011). Interestingly, these studies provide some information on the types of instructional adjustments teachers make but only from the teacher’s perspective.
According to Blanc et al. (2011), a common response to data by teachers is to devote instructional planning in identifying students of concern and planning remediation or review. In this particular study, teachers focused their energy on identifying students who were just below the target of performance. These students are often referred to as “on the bubble” because of their close proximity to proficiency (Datnow & Hubbard, 2015). Christman and colleagues’ (2009) study further collaborated these findings by noting that the identification of this student population was a common practice. As teachers engaged in data dialogues, they planned interventions to address the needs of these particular students.

Still, focusing on these “on the bubble” students is not the only way in which teachers respond to data. Hoover and Abrams (2013) contend that while the teachers they surveyed did not analyze data frequently or with the depth required to obtain the full benefits, most of the teachers in the study reported making instructional changes of assessment data. A total of 96% of teachers reported differentiating instruction for remediation, 94% of teachers reported reteaching, and 92% changed the pace of future instruction. At the same time, 64% of teachers said that the pacing prevented reteaching, which appears inconsistent with the fact that most of them reported reteaching. Note that these findings were self-reported by teachers, which does not allow for a full depiction of the types of instructional changes that result from data.

In a recent case study of five low-income, high needs middle schools in three districts, Farrell and Marsh (2016) provide additional insights into the types of response teachers employ as a result of a data-driven decision making. Specifically, they better define the four different types of instructional responses that emerged from the analysis of various data sources. These types of instructional change included change in delivery, reteach and retest, small groups, and student analysis. Farrell and Marsh (2016) describe a change in delivery as the way in which a
teacher reorganizes how students acquire information or skills. In this case, a teacher could adopt a single strategy that they only employ once, or a teacher could engage in a long-term pedagogical shift. For example, a teacher could utilize the results from a formative assessment to determine that students do not understand the literary concept of “flashback.” Instead of restating the definition, as was previously employed, the teacher decides to play a video clip from a movie where a “flashback” occurs.

Reteaching and retesting, on the other hand, is employed when a teacher, for example, discovers that based on a district benchmark assessment, students are not proficient with the concept of plot. In response to this outcome, the teacher provides instruction over the concept in the same manner as previously employed. Once the concept has been retaught, the teacher retests the students to see if the additional exposure to content improves student performance. Another response that a teacher might utilize in response to data is the utilization of small groups. Based on the data from a given assessment, a teacher may choose to pair or group students homogeneously. The teacher will then provide instruction that is tailored to the needs of a specific group. Note that a teacher may or may not change the delivery of instruction within the context of the small group.

Finally, Farrell and Marsh (2016) identify student analysis as a fourth response that teachers may employ as a result of data obtained from a district benchmark assessment. In this case, a teacher may have students review their own personal results to the assessment and then reflect on areas of proficiency. Additionally, the teacher could require the students to identify content that they found challenging and devise strategies for improving proficiency. While the work of Farrell and Marsh (2016) better defines types of instructional responses, once again these responses are self-reported and could be strengthened by observational data.
Response by assessment type

Although some studies point to the potential for data to substantively inform and shape teachers’ practice (Hamilton et al., 2009; Konstantopoulos, Miller, & van der Ploeg, 2013; Marsh, 2012; Nelson, Slavit, & Deuel, 2012), others indicate that teachers may not significantly alter their instruction in response to data (Ikemoto & Marsh, 2007; Ola’h, Lawrence, & Riggan, 2010). This may be due in large part to the type of assessment teachers examine during the data-driven decision-making process. In a 2016 study, Farrell and Marsh examined how teachers responded to data generated from four different assessment types, including state assessments, district benchmark assessments, common grade-level assessments, classroom assessment data and student work.

Farrell and Marsh (2016) define a state assessment as a standardized, yearly multiple-choice assessment administered by the state, which the majority of students are required to take. The study found that state assessment data were seen as valuable because of their format. Specifically, this is because teachers could disaggregate the previous year’s data by proficiency level for various groups of students. Overall, teachers utilized this data to develop an initial understanding of their students’ strengths and weaknesses. However, as the school year continued, the data became stale and was of very little use.

District Benchmark or interim assessments, on the other hand, are defined by Farrell and Marsh (2016) as multiple-choice tests administered three times a year, reflecting state content standards. Interestingly, teachers had varied reactions to this type of assessment. On the positive side, half of the teachers reported that benchmark assessments enabled them to determine how students were progressing toward end-of-year benchmarks, which would later be measured by state assessments. Still, many of these same teachers indicated that they did not trust the
assessment design as they were developed by an external source. Note that in this instance, the mental model, *nature of the test* (Bertrand & Marsh, 2015) is being applied by the teachers in this study. Recall that *nature of the test* indicates the following decisions of the teacher: the locus of causality is external, and the outcome is stable and uncontrollable. Note that this model predicts that the probability of instructional change is low. Interestingly, interim benchmark assessments had the most mixed set of opinions from teachers by far.

Next, Farrell and Marsh (2016) define common grade assessments as multiple choice or short answer assessments developed by groups of teachers who taught the same courses. For example, take a language arts quiz developed by a seventh-grade team. Again, over half of the teachers in the study valued these types of assessments because they had developed them in alignment with the standards attended to in their instruction. Furthermore, these assessments were developed and administered across all classes. As a result, teachers were able to compare results with each other and share possible strategies to improve instruction. Finally, these types of data were valued because they were designed to predict future success. Here again, teachers applied the *nature of the test* mental model of sensemaking (Bertrand & Marsh, 2015). However, in this case the teachers saw the locus of causality as internal and the outcome as stable and controllable. As such, this mental model predicts that teachers will be more likely to employ changes to instruction. Recall that this particular mental model can predict two different results that are dependent upon whether or not teachers had a role in the creation of the test. Still, while this mental model predicts a change in instruction, the change in this case may be limited only to adjusting the way in which various questions are presented on the common-grade assessment.
The final assessment type, student work, is defined to be a written assignment or project designed by the classroom teacher. Interestingly, Farrell and Marsh (2016) found that this particular assessment type created the greatest opportunities for changes in delivery. Teachers indicated that they highly valued these types of assessments because of their alignment to instruction and quick turnaround. Among all of the data discussed, student work was valued for providing insight into an individual student’s understanding and thinking. Additionally, student work provided information about student achievement in terms of a developmental process instead of a particular outcome measure.

**Chapter 2 Closure**

In summary, the educational community is in need of a more in-depth description of how teachers respond to data. In particular, a better understanding of changes in instructional delivery is needed. The purpose of my multiple case study will be to provide an in-depth description of instructional changes by observing how teachers utilize the Delta Math readiness lessons. Note that Delta Math provides teachers with instructional resources to respond to the specific needs of students identified as at-risk via the readiness screener. By empowering the teacher to employ the various instructional strategies from gradual release of responsibility to concrete, representational and abstract, teachers will respond to the needs of students in a way that supports student achievement.
CHAPTER III

METHODS

The purpose of this multiple case study is to describe and interpret how teachers in grades first-through-fifth engage in sensemaking of data obtained from the Delta Math Readiness Screener. Using a modified theoretical framework established by Bertrand and Marsh (2015) that employs three distinct lenses, namely a reconceptualization of the data cycle, attribution theory, and sensemaking, I intend to describe the mental models that are applied as teachers engage in the data cycle. Additionally, this study investigates the types of instructional changes that are employed as a result of the application of mental models. This study is guided by the following research questions:

1. What types of mental models are applied during sensemaking within the Delta Math RtI Program data cycle?
2. How do these mental models change over the course of the school year?
3. What types of instructional change result from the application of these mental models?

Research Design, Approach, and Rationale

The qualitative approach utilized to shed light on these research questions is a multiple case study. According to Merriam (1998), a case study is a holistic description of a bounded phenomenon. A phenomenon could be described in one of the following ways: a program, an institution, a person, a process, or a social unit. The bounded system this study investigates is the process of sensemaking of data obtained from the Delta Math readiness screener and the resulting changes in instruction employed by an elementary educator. Yin (2018) claims that case study methodology is appropriate if the following are true: the main research question is
“how” or “why,” there is little or no control over the behavioral events, and the focus of a study is on a contemporary phenomenon investigated within a real-world context. Given that I have no control over this contemporary phenomenon and that the research questions attend as to how teachers make sense of data, case study is an appropriate way to conduct research on this topic.

My approach to case study methodology is aligned with constructionism. Unlike the positivist view that one real truth exists, constructionists believe that truth and reality are not discovered but are reconstructed by people within their everyday contexts (Charmaz, 2008; MacDonald & Schreiber, 2001). Constructionism is rooted in context and maintains that different versions of truth are valid (Duncan et al., 2007; White, 2004). Because I am interested in how teachers make sense of and respond to data, having this type of orientation is essential to understanding and describing the phenomenon under review. As such, I am seeking to capture the various realities of the participants by working collaboratively with them. This, in turn, enables me to bring clarity to the beliefs and actions of the participants (Baxter & Jack, 2008).

Data collection for this case study drew from multiple resources including observations and semi-structured interviews. Through data collection, a detailed description of the case emerged. An analysis of themes was conducted to identify key issues embedded in the description.

**Population, Sample and/or Site**

Participants were purposefully selected to help describe the types of mental models teachers apply to data obtained from the Delta Math screener and the types of instructional changes that are employed as a result of these mental models. The following criteria were utilized in the selection process of participants:
a. Participants teach in an elementary building that has three to five teachers per grade level.

b. Participants belong to a building that screens their students, using the Delta Math Readiness screener, three times per year.

c. Participants must have conducted grade-level data meetings three times per year to review the Delta Math data.

d. The grade-level team must have utilized the Delta Math protocols to facilitate the meeting.

In order to gain access to a site that meets the above criteria, I contacted the creator of Delta Math, Mike Klavon of the Ottawa ISD, to obtain a list of districts and building administrators in Berrien County. These administrators were contacted via telephone and a brief overview of the study was communicated to them (Appendix A). If the administrator was interested in having one grade level of teachers participate, a recruitment email (Appendix B) along with the consent form (Appendix C) was sent to potential participants. Those interested in participating were asked to email or fax the consent form to me and/or call for any necessary clarifications. I contacted the participants via email or telephone to thank them for their participation and scheduled their first interview. Once all initial interviews were conducted, I scheduled a time to conduct the observation of the first data review with the participating administrator. Once the observation had been conducted, I scheduled follow-up interviews with all of the participants. In total, three observations and up to 20 interviews were conducted over the course of the 18-19 school year.

Data Collection Procedures and Instrumentation

Data for this study was collected via observations and semi-structured interviews. Observation was considered a fundamental method in qualitative inquiry and enabled the
researcher to discover complex interactions in social settings (Marshall & Rossman, 2016). Over the course of the 18-19 school year, I observed the three data team meetings that occur within the Delta Math screening cycle. During the observations, I assumed the role of a non-participant/observer. In this role, I observed and took notes without direct involvement (Creswell, 2013). I utilized an observational protocol to record information. This protocol included the following information: date of observation, location, type of setting, time spent in setting, and descriptive notes and reflective notes (Appendix D).

While observations enable the researcher to observe the phenomenon in action, interviews “allow the researcher to understand the meanings that everyday activities hold for people” (Marshall & Rossman, 2016, p. 150). These researchers describe an interview as a site where two or more individuals discuss a common theme (p. 147). A maximum of five teachers were interviewed for this study. Participants were interviewed four times during the course of this study (Appendix E). Teachers were interviewed one-on-one before the first screening and then two-to-four weeks after each data review meeting. These interviews occurred at a time and place convenient for both researcher and the educator.

**Data Analysis**

First, I sent the initial interviews out for transcription. Once transcription was complete, I created an executive summary of each interview and sent it to each teacher to review. This helped to ensure trustworthiness throughout the data analysis process. Next, I identified any information of interest and composed a brief summary of my initial impressions of the data and discuss sections of interests (Richards, 2015). Then, I applied In Vivo Coding to the interview. According to Saldana (2015), this type of coding uses the terms of the participants and “captures the behaviors or processes which will explain to the analyst how the basic problem of the actors
is resolved or processed” (p. 109). Additionally, it helps preserve the participant’s meanings of their views, which is in alignment with my views of constructionism. These codes were then organized into three primary topics: applied mental models, responses to data, and other. These topics were then organized into categories. Based on the mental models codes, a participant fell in one or more of the following categories: instruction (Model 1), student understanding (Model 2), nature of the test (Model 3) and student characteristics (Model 4). See Appendix H for a description of the categories. Based on the instructional change codes, a participant could fall in one or more of the following categories: reteach, regroup, student reflection, change in delivery, or no instructional change. The topic “other” will be emergent.

After coding and categorizing the first round of interviews, I summarized, reflected upon and compared my findings to my initial impressions of the data. Next, I coded and categorized the field notes from the observations in a similar fashion. While the focus was on the application of mental models, instances of potential instructional change emerged. This system of analysis occurred in a similar manner for the remaining three interviews and two observations. Throughout this process, In Vivo codes for the mental models and instructional changes were organized in a color-coded table.

After coding, categorizing, and interpreting the observation and interviews, I created a 3D model that visually represents the mental models that were applied and the instructional strategies that were utilized within this bounded system. I used this visual to compose a rich description of each participant’s instructional changes and applied mental models. Over the course of the 18-19 school year three, 3D models were created to represent each data review meeting and the corresponding interviews. Finally, an overall synthesis of the study was
developed to describe and interpret how teachers utilize data from Delta Math and the types of instructional changes that are employed.

Throughout the analysis process, I maintained a code book which included a description of the code along with exemplars. Additionally, I maintained analytic memos that addressed the following: how I relate to the participants and the context, emergent patterns, categories, themes, concepts, and assertions, any problems with the study, ethical dilemmas, future directions for the study, and tentative answers to the study’s research questions (Saldana, 2016).
### Summary: A Crosswalk for Research Questions, Data Sources, and Data Analysis

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Data Source</th>
<th>Data Analysis Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>What types of mental models are applied during sensemaking within the Delta Math RtI Program data cycle?</td>
<td>Observation Protocol (To be conducted at three different data review meetings)</td>
<td>In Vivo Coding, categorizing and interpretation of observations and interviews. 3D Models were created to represent each data review meeting and corresponding interviews.</td>
</tr>
<tr>
<td>How did these mental models change over the course of the school year?</td>
<td>Observation Protocol (Conducted at three different data review meetings)</td>
<td>In Vivo Coding, categorizing and interpretation of observations and interviews. 3D Models were created to represent each data review meeting and corresponding interviews. Overall synthesis of 3D models articulated change over the course of the 18-19 school year.</td>
</tr>
<tr>
<td>What types of instructional change resulted from the application of these mental models?</td>
<td>Observation Protocol (Conducted at three different data review meetings)</td>
<td>In Vivo Coding, categorizing and interpretation of observations and interviews. 3D Models were created to represent each data review meeting and corresponding interviews.</td>
</tr>
</tbody>
</table>
The Researcher and Reflexivity

According to Creswell (2014), one must consider their own background, interests and what they bring to research. Furthermore, “researchers have a personal history that situates them as inquirers. They also have an orientation to research and a sense of personal ethics and political stances that informs their research” (p. 51). I believe that it is important for me to disclose that I was both a middle and high school math teacher for 12 years. During that time, I served as the middle school mathematics department head and was responsible for facilitating data meetings and creating interim assessments. Through the Aspiring Principals Cohort at Western Michigan University (2011-2013), I supported my school in the utilization of data-driven decision-making protocols, so that all educators could better analyze data to inform instruction. From 2013 to 2017, I served as the K-12 mathematics consultant for Berrien County. In that role, I was responsible for supporting teachers in utilizing Delta Math to support their intervention block. Currently, I serve as the Director of Curriculum, Instruction and Assessment at Niles Community Schools.

I believe that my prior experiences supported my ability to better understand and interpret the data meetings I observed in this study. Because I have both facilitated and experienced this phenomenon, I further believe that I was able to tune into behaviors that a novice might not be able to. I also recognize that my prior experiences may have impaired my ability to shape my findings in an unbiased fashion. Additionally, my experiences may have impacted how I interacted with participants during the interview process. Because of my knowledge of data utilization and best practices in mathematics education, it was important for me to assume a listening posture and not resort to coaching a teacher on how to utilize data to improve
instruction. In summary, it was critical that I attended to my role as a researcher and not fall into the role of coach or consultant.

**Trustworthiness**

According to Marshall and Rossman (2016), “articulating the elements of sound design for trustworthiness has been critical for the development of qualitative methodologies” (p.44). In qualitative inquiry, the researcher is “the instrument,” but calling herself reliable isn’t sufficient. Instead, we must distinguish the traits that make us personally credible and ensure that our interpretation of the data is “trustworthy” (p. 44). In other words, as a qualitative researcher, it is critical that I articulated the systems that ensure the trustworthiness of my data collection processes. Lincoln and Guba (1985) provide the following constructs to capture these concerns: credibility, dependability, confirmability, and transferability. They also provide procedures to ensure that trustworthiness is realized. For credibility, they urge qualitative researchers to be in the setting for a long period of time (prolonged engagement). Regarding this study, I was working with up to five teachers for approximately a year. In regards to reliability, I shared data and interpretations with participants by conducting member checks. During the interview process, I continually provided my participants with opportunities to check whether or not I have correctly captured their thoughts during the process. Finally, in regards to transferability I triangulated my findings by gathering data from multiple sources. Thus, any conclusions are likely to be more convincing and accurate if they are based on several different sources of information, following a similar convergence. By developing convergent evidence, data triangulation helps to strengthen the construct validity the study” (Yin, 2018).
Limitations and Delimitations

By definition, delimitations narrow the scope of a study. In this instance, the case study confined itself to interviewing and observing one grade level team of up to five elementary teachers in one school in Berrien County. This study was also confined by the data source. Specifically, I only investigated the mental models and instructional changes that are applied to data obtained from Delta Math.

Limitations, on the other hand, are factors that are outside my control as a researcher. These factors include participant drop out, data review meetings that do not adhere to the protocol, and participants not able to participate in all the required interviews. Additionally, we cannot make causal inferences from case studies, because alternative explanation cannot be ruled out. This case study reflects the behavior of the selected group, and this behavior may or may not be the same in similar groups.

Chapter 3 Closure

In conclusion, this multiple case study investigated the mental models that teachers apply to data obtained from the Delta Math Readiness screener. Additionally, this study provided the field with a detailed description of the types of instructional changes teachers employed as a result of the applied mental model. Both observations and semi-structured interviews served as the instruments I utilized to capture this unique phenomenon situated within a real-life context. Ultimately, this study supported school administrators in determining whether or not the data obtained from Delta Math will support instructional change. As previously mentioned, both educators and administrators are constantly bombarded by data; and, therefore, it is important to identify data sources that promote instructional changes.
CHAPTER IV
PRELIMINARY RESULTS BY CHRONOLOGICAL ORDER

The purpose of this multiple case study is to describe and interpret how teachers in grades first-through-fifth engage in sensemaking of data obtained from the Delta Math Readiness Screener. Using a modified theoretical framework established by Bertrand and Marsh (2015) that employs three distinct lenses, namely a reconceptualization of the data cycle, attribution theory, and sensemaking, I intend to describe the mental models that are applied as teachers engage in the data cycle. Additionally, this study investigated the types of instructional changes that are employed as a result of the application of mental models. The study was guided by the following research questions.

1. What types of mental models are applied during sensemaking within the Delta Math RtI Program data cycle?
2. How do these mental models change over the course of the school year?
3. What types of instructional change result from the application of these mental models?

Overview of Study

During the 2018-2019 school year, three fourth-grade teachers from an elementary school in southwestern Michigan began their initial implementation of the Delta Math Readiness screener. Additionally, the participants of this study were required by their administrator to conduct a half-hour intervention block each day. The purpose of this intervention block was to remediate students who had not mastered critical third and fourth grade math content. The teachers refer to the intervention block as WINN (What I need now) time. The district provided text for grade level or core instruction was the 4th Grade edition of Go Math.
In order to maintain participant anonymity, the three teachers are referred to as Teacher W, Teacher K and Teacher S. Unlike her colleagues, teacher K taught a 4th/5th split. The split contained eight academically high fourth graders and 12 academically low fifth graders.

Before implementation, I interviewed each participant to better understand how they typically applied mental models to various data sources and the types of instructional change employed. The participants screened their students in the fall, winter and spring using the Delta Math Readiness screeners. Upon the conclusion of each screening, I observed the fourth grade team conduct a review of the data. This data review was facilitated by the Berrien RESA mathematics consultant. After each data review, I conducted a follow-up interview with each of the participants. Upon the conclusion of the interviews, participants were provided a summary to ensure the accuracy of my interpretations. All participants agreed with my interpretations of the various interviews.

The following narrative summarizes key findings from the three observations and 12 semi-structured interviews with three fourth grade teachers. From October 2018 until June of 2019, this multiple-case study was conducted in the following order as described in Figure 5 below.
### Figure 5. Case study timeline

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Interviews</td>
<td>Fall Data Review</td>
<td>Winter Data Review</td>
<td>Spring Data Review</td>
<td>Spring Data Review Follow-Up Interviews</td>
</tr>
<tr>
<td>Fall Data Review Observation</td>
<td>Follow-Up Interviews</td>
<td>Observation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Summary of Participant Interviews and Observations

**Initial Interview: Teacher W**

Teacher W is a 15-year veteran of education with a master’s degree in reading. She has spent her entire career at the same district located in southwestern Michigan. She has taught kindergarten, second grade and fourth grade.

Teacher W acknowledges that her current fourth grade students have been academically low throughout their school career. However, she is determined to improve student achievement. As such, she responded immediately and changed instruction based on classroom assessments.

Overall, she does not find the results from state tests, like M-Step, actionable or useful in guiding her instruction.

With regards to district level assessments such as NWEA, DIBELS, and Delta Math, teacher W, noted that the district has often changed the emphasis and utilization of these assessments. When we discussed Delta Math specifically, she was excited by the potential impact on her instruction. She also explained how the data could help her establish a baseline understanding of her students.
Teacher W holds herself accountable for the results of her classroom data and changes instruction based on those results. Specifically, she employs small group instruction and reteaching.

**Initial Interview: Teacher K**

Teacher K is a 24-year veteran who has spent the majority of her career in grades 3 and 4. Currently Teacher K is teaching a 4th/5th split. When deciding what to teach, Teacher K explained that she utilizes the district pacing guides and focuses on the power standards. When deciding how to teach, she first reviews the strategies in the Go Math text. Then, depending on whether or not she believes that the strategies are effective, she utilizes other strategies like games, hands-on activities or videos.

She believes that if students have been sufficiently prepared for state assessments like M-STEP, their performance will be adequate. However, if a student is emotionally distressed during the test, the outcomes will not be favorable. One way Teacher K has control over the outcomes to a state assessment is to ensure that the testing environment is calm. Like the majority of her colleagues, Teacher K does not find the M-STEP data useful enough to impact instructional change.

When asked to reflect on the data obtained from district level assessments, Teacher K noted that data acquired in the middle or end of year were more significant than at the beginning of the school year. She believes this because students better understand her high expectations at those points in the school year. Teacher K revealed that she plays an integral role in preparing students for district level assessments. Three ways that Teacher K responds to district level data are student reflection, reteaching, and regrouping.
Finally, Teacher K noted that attendance and her instruction had the most significant impact on classroom assessments. When reviewing results to these assessments, she again noted the following instructional changes: student reflection, reteaching, change of strategy, and regrouping. Teacher K also holds herself accountable for her classroom data and will change instruction based on those results. The interview revealed that she has utilized small group instruction and reteaching as means of instructional change.

Initial Interview: Teacher S

Teacher S has taught three years in her current district as a fourth-grade teacher. She acknowledges that her students are low and makes adjustments accordingly. She considers herself a traditional teacher, but her pedagogy can change as needed based on the independence of the students. Teacher S noted in her interview that she is data driven and often uses district data sources to inform her instruction.

Teacher S does not find the M-STEP test results helpful in guiding her instruction. She explained that the data from this assessment is not timely and if a student struggles in reading, it will have an impact on the math scores. Teacher S also cited demographics and parent involvement as factors that contribute to outcomes on state assessments like M-STEP. Overall, teacher S feels she has little control over these test results.

With regards to response to district assessments, Teacher S finds this data source a more valid measure of her students strengths and weaknesses. In fact, she was excited that reviewing these results would enable her to better support her students. Specifically, these results would help her identify specific areas for growth. A strategy that she uses to improve results, on these assessments, are rewards systems. Students who show growth on these assessments are rewarded with movies, popcorn, and pop.
Finally, Teacher S attributes outcomes on classroom assessment to student confidence. While confidence does play a role in student outcomes, she also takes ownership for her own instruction. In response to poor performance, teacher S will identify common misconceptions and then reteach the lesson.

**Fall Data Review**

On October 10th, 2018, I observed the fourth grade team’s first Delta Math Data Review. This review was conducted by the Berrien RESA mathematics consultant. The consultant led the team in utilizing a structured protocol created by the Delta Math Program. However, the consultant did not follow the protocol exactly as written. During this observation, the district superintendent was present. The teachers reviewed the following data set, see Table 2 below.

**Table 2**

*Results from the Fall 2018 Delta Math Fourth Grade Readiness Screener*

<table>
<thead>
<tr>
<th>Common Core Delta Math Readiness Standards</th>
<th>Percent of Students Below Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.NBT.2a - Add three-digit numbers</td>
<td>36%</td>
</tr>
<tr>
<td>3.NBT.2b - Subtract two-digit numbers</td>
<td>73%</td>
</tr>
<tr>
<td>3.OA.7a - Multiply numbers from 0-10</td>
<td>61%</td>
</tr>
<tr>
<td>3.OA.7b - Divide numbers from 1-10</td>
<td>95%</td>
</tr>
<tr>
<td>3.NF.1 - Identify fractions and their parts</td>
<td>25%</td>
</tr>
<tr>
<td>3.NF.2 - Name fractions on a number line</td>
<td>59%</td>
</tr>
<tr>
<td>3.NF.3d - Compare fractions with the name</td>
<td>76%</td>
</tr>
<tr>
<td>numerator or denominator</td>
<td></td>
</tr>
</tbody>
</table>

The teachers also reviewed individual reports that organized groups of students by readiness standard. For example, Teacher K was able to ascertain which of her students needed additional support with Readiness Standard 1-Add three-digit numbers.
Overall, teachers were not surprised by the data. In this case, overall student performance was very low. Teacher W explained, “The grade has always been low, and that has been the excuse. And nothing has ever been about it. The data is not surprising. They are not ready for fourth grade.”

Interestingly, the protocol, along with the support of the math consultant, allowed the teachers to move past the low skills of their students and begin creating a plan to address student needs. Immediately after reviewing the data, the math consultant provided the team with a calendar to sketch out interventions through November. In doing so, the team was committed to remediating each standard every two weeks during WINN (What I Need Now) time. This schedule could provide several opportunities for the teachers to conduct small group instruction, have students reflect on their progress, reteach and change the delivery of instruction.

**Fall Data Review Follow-Up Interview: Teacher W**

Teacher W believes that results from the fall Delta Math readiness screener were an accurate reflection of what her students knew and did not know. The results confirmed her suspicion that the majority of her fourth graders were not on grade level for mathematics.

Initially, she was overwhelmed by the amount of content that her students did not know. However, Delta Math allowed her to reflect on key readiness skills. She is currently using the lessons provided by the program in both whole group and small group settings. As a result of the lessons, she is engaging in pedagogical strategies that she has not utilized in the past. When asked why she chose to use lessons and try unfamiliar strategies, she cited that she was so overwhelmed by several new school initiatives that she just decided to “go with it and hope for the best.”
Teacher W also noted that she continues to use the Delta Math lessons because the students find them engaging and are showing progress. Students are graphing their progress using the quick check results. This is allowing them to see that over time they can achieve mastery. Additionally, Teacher W stated that students really enjoyed utilizing manipulatives to solve problems. Overall, Teacher W is noticing positive changes in her students.

Teacher W has engaged in utilizing the resources within Delta Math to guide instruction during her intervention block or WINN (What I Need Now) time. As a result, she is utilizing new instructional strategies and engaging in a change of delivery. Additionally, the resources are also supporting student reflection. Specifically, by charting their progress on the quick checks, students seem to be motivated to improve. As students continue to demonstrate a change in understanding, Teacher W continues to engage in the Delta Math Lessons.

Another interesting instructional change to notice is that data obtained via Delta helped Teacher W to determine when small group intervention was appropriate and when whole group intervention was necessary. Delta Math recommends that if the majority of the grade level is not at benchmark on a given standard, then all students should receive intervention. Therefore, depending on the results of a particular readiness standard, Teacher W will structure her WINN time accordingly.

**Fall Data Review Follow-Up Interview: Teacher K**

Like Teacher W, Teacher K also believes that the results from the Delta Math screener are an accurate reflection of her students’ skills in mathematics. In addition, she believes that the scores could have been higher if students had double-checked their work. Specifically, Teacher K noticed that several students made careless arithmetic errors. She hopes that she can better support them in intentionally checking their work.
Teacher K also found the data helpful in identifying gaps in student understanding. In this case, she saw that students needed additional support with multi-digit subtraction. In response to the identified gap, she has changed her instruction in the following ways. First, she is providing her students with access to different strategies for solving multi-step subtraction problems. Specifically, the Delta Math lessons provided her an opportunity to try mathematical drawings as a means to support students in their conceptual understanding of subtraction. Teacher K noticed that several of her students were just “crossing off” numbers with no rationale. However, through the use of drawings, students began to understand the process. Initially, her students resisted this strategy, but, over time, they had better success with subtraction.

The second way Teacher K changed her instruction was by grouping her students differently during core instruction. Prior to screening, she tried to teach her 4th/5th split as one whole group. Now she separates them into smaller groups to better address their needs. Additionally, she brings the whole group together so that they can share out what they have learned. This allows her to better manage two grade levels in one classroom.

**Fall Data Review Follow-Up Interview: Teacher S**

While Teacher S does cite some reasons for why her Delta Math data might be skewed, i.e. summer slide and students transferring answers from paper to the screen, she believes that the data is an accurate reflection of what her students know. The results of the screener confirm that her fourth graders are academically low in mathematics.

One way that Teacher S has used the data obtained from Delta Math is to help make decisions around prioritizing lessons in the Go Math! text. This, in turn, has affected her pacing in core instruction. With her teaching partner, Teacher S makes decisions regarding which lessons are not appropriate for her students. Additionally, the data supported her in making the
decision to slow down her pacing in core instruction. Finally, Teacher S uses the data to form small groups and reteach particular skills.

**Winter Data Review**

On February 4th, 2019, I observed the fourth grade team’s Winter Delta Math Data Review. This review was conducted by the Berrien RESA mathematics consultant. The consultant led the team in utilizing a structure protocol created by the Delta Math Program. Again, the consultant did not follow the protocol exactly as written. During this observation, the building interventionist was present. The teachers reviewed the following data set, see *Table 3* below.

**Table 3**

*Results from the Winter 2019 Delta Math 4th Grade Readiness Screener*

<table>
<thead>
<tr>
<th>Common Core Delta Math Readiness Standards</th>
<th>Percent of Students Below Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.NBT.2a - Add three-digit numbers</td>
<td>9%</td>
</tr>
<tr>
<td>3.NBT.2b - Subtract two-digit numbers</td>
<td>19%</td>
</tr>
<tr>
<td>3.OA.7a - Multiply numbers from 0-10</td>
<td>28%</td>
</tr>
<tr>
<td>3.OA.7b - Divide numbers from 1-10</td>
<td>62%</td>
</tr>
<tr>
<td>3.NF.1 - Identify fractions and their parts</td>
<td>9%</td>
</tr>
<tr>
<td>3.NF.2 - Name fractions on a number line</td>
<td>8%</td>
</tr>
<tr>
<td>3.NF.3d – Compare fractions</td>
<td>15%</td>
</tr>
</tbody>
</table>

As the teachers reviewed the data, they noticed that for each readiness standard there was a decrease in the number of students not at benchmark. The math consultant asked the team to identify both strengths and weaknesses. Teacher S stated, “My kids did the best on adding three digits and fractions on a number line. Timed division was not good.” Teacher W then noted, “Timed division was not good, and I thought we would do better on three-digit subtraction.” The
math consultant then reminded the team about the amount of progress that was made from fall to winter.

Teacher W then noted the barriers around the timed section of the screener. In order to achieve benchmark on 3.0A.7b, students must get 10 division problems correct in a minute. To support the team in moving past this barrier, the math consultant suggested increasing the time to two minutes. This strategy will help them determine which students just need additional practice with their division facts and which students need explicit instruction via the Delta Math Lessons.

The math consultant then asked the team to create a list of strategies that they employed from fall to winter that resulted in more students achieving benchmark. Teachers K and W noted the following: students charted progress on their quick checks; students practiced strategies from the Delta Math Lessons; students worked with partners; students learned strategies to help them check their work; teachers incorporated more games; teachers rewarded students for meeting goals, and teachers organized quick checks and growth charts in binders for students. Teacher W also discussed how it was so important for her to “stick to the program” and made time for interventions every day. Interestingly, Teacher S did not contribute any strategies to the list.

Next, the team reviewed the results from the 5th grade readiness screener, see Table 4 below.
Table 4

Results from the 2019 Winter Delta Math 5th Grade Readiness Screener

<table>
<thead>
<tr>
<th>Common Core Delta Math Readiness Standards</th>
<th>Percent of Students Below Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.NBT.5 - Multiply multi-digit numbers</td>
<td>53%</td>
</tr>
<tr>
<td>4.NBT.6 - Divide up to a four-digit number by a one-digit number</td>
<td>100%</td>
</tr>
<tr>
<td>4.NF.2 - Compare two fractions</td>
<td>32%</td>
</tr>
<tr>
<td>4.NF.3b - Convert between improper fractions and mixed numbers</td>
<td>91%</td>
</tr>
<tr>
<td>4.NF.3c - Add and subtract mixed numbers</td>
<td>92%</td>
</tr>
<tr>
<td>4.NF.4b - Multiply a whole number by a fraction</td>
<td>64%</td>
</tr>
</tbody>
</table>

As the teachers reviewed the results from the fifth grade readiness screener, there was a noticeable change in the meeting. The participants quickly went from celebrating their success on the fourth grade screener to being overwhelmed by the lack of students who had reached benchmark on the fifth grade screener. Teacher S noted, “Oh, we are back to where we started!” While Teacher W explained, “We struggle with the prerequisites; they came in so low, and we know we need to get to fractions.” The math consultant provided the teachers with calendars to scope out their intervention work for the next few months. However, unlike the fall meeting where the participants began to plan two-week cycles for each standard, the teachers began to question whether or not the fifth grade readiness standards could be utilized in their core instruction. Teacher W asked the math consultant, “So I have a question for just this year. In my mind, we are so far behind, can we just use Delta for our lessons?” In response to Teacher W’s question, the math consultant replied: “Using your professional judgement, you could try the Delta lessons. But Delta math is not your core curriculum How could you couple these, Delta and Go Math!”
As the meeting was quickly coming to an end, the teachers continued to discuss the possibility of abandoning their core text Go Math and their pacing guide, so that they could focus exclusively on the fifth grade Delta Math Readiness Standards. Unlike the fall meeting, the teachers ultimately left without a solid plan for interventions in place.

**Winter Data Review Follow-Up Interview: Teacher W**

Overall, Teacher W found that the data from both the fourth grade readiness and the fifth grade readiness screeners to be an accurate reflection of student understanding. She was surprised by the results of the timed division facts. Specifically, some of her students performed lower than she anticipated. However, based on the recommendation of the math consultant, she provided some students with additional time to complete their division facts. This assessment modification allowed her to determine which students were lacking in their conceptual understanding versus who needed more practice completing their facts in the allotted time. Teacher W expressed that this modification allowed her to be more targeted with her students during intervention.

Again Teacher W expressed how her class has historically been low. As a result, she was not surprised that the results on the fifth grade readiness screener did not indicate mastery of fourth grade content. Teacher W was frustrated by what she sees as a lack of accountability amongst her peers in the prior grade levels. Teacher W explained that there have been several conversations around the “must haves” in each grade level. However, she feels her colleagues have not been held accountable in ensuring that all students master the “must haves.”

Teacher W does not believe that Delta has impacted her instruction. However, Delta has supported her in grouping students, reteaching and asking students to reflect on their learning. Delta also allows her to make decisions around pacing. Currently her students are bend in their
scope and sequence and she is considering using the Delta Math readiness standards to prioritize her content for the remaining 12 weeks.

**Winter Data Review Follow-Up Interview: Teacher K**

Overall, Teacher K found both the fourth grade and fifth grade readiness screeners to be a good measure of her students’ skills. With regards to the fourth grade readiness screener, Teacher K noticed that students were still struggling with the timed facts for multiplication and division. Interestingly, she noted that they “knew” their facts, they just couldn’t complete them in the required minute. In regard to the fifth grade readiness screener, Teacher K explained that while many students were not at benchmark, she was not surprised, as she had not taught all the content assessed on the screener.

Teacher K also found the data obtained from the screener to be helpful. Specifically, it allowed her to focus on specific skills with specific students. As such, she is utilizing the data to strategically group her students. Additionally, the data has prompted her to rearrange the scope and sequence of her instruction so that the same topics can be addressed in both core instruction and intervention. Finally, she continues to review Delta math readiness standards during her core instruction in order to ensure that students are having additional opportunities to explore those concepts.

**Winter Data Review Follow-Up Interview: Teacher S**

After reviewing the data from the fourth grade and fifth grade readiness screeners, Teacher S stated that she believes that the data is a valid reflection of what her students know. Teacher S also noted the amount of hard work she and her students have done around the fourth grade readiness standards during the intervention block.
Teacher S is using the data from both screeners in a variety of ways. The results from the fourth grade readiness give her insight into which students already have the concepts and which students need additional practice. This allows her to be very targeted in her instruction.

Additionally, the results from the fifth grade readiness allow her to plan her core instruction throughout the year. Specifically, it allowed her to prioritize critical skills and concepts to ensure that students have the foundation necessary for success.

With regard to changes in instructional practice, Teacher S is using the data to create small groups that are focused on specific skills. The quick checks provide her immediate feedback that allows her to determine what she may need to reteach. According to Teacher S, Delta has had a huge impact on her class, which she describes as academically low. Specifically, she has seen improvements with fact fluency. Additionally, Teacher S has changed her delivery of comparing fractions. Instead of the butterfly method, she is using the number line and building conceptual understanding of the numerator and denominator. As a result of utilizing the Delta Math Lessons, Teacher S has realized that while the butterfly method is a quick and efficient way to compare fractions, it does not support student understanding.

Delta has empowered Teacher S to use more conceptually-based strategies when comparing fractions, a third grade standard. Like her colleagues, Teacher S also utilized the data to prioritize her core instruction. Additionally, she has used the quick checks as formative assessments of the core content in order to help her decide next instructional steps.

**Spring Data Review**

On May 31, 2019, I observed the fourth grade team’s Spring Delta Math Data Review. This review was conducted by the Berrien RESA mathematics consultant. The consultant led the team in utilizing a structure protocol created by the Delta Math Program. Again, the consultant
did not follow the protocol exactly as written. The teachers reviewed the following data set, see

*Table 5* below.

**Table 5**

*Results from the Spring 2019 Delta Math 4th Grade Readiness Screener*

<table>
<thead>
<tr>
<th>Common Core Delta Math Readiness Standards</th>
<th>Percent of Students Below Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.NBT.2a - Add three-digit numbers</td>
<td>7%</td>
</tr>
<tr>
<td>3.NBT.2b - Subtract two-digit numbers</td>
<td>9%</td>
</tr>
<tr>
<td>3.OA.7a - Multiply numbers from 0-10</td>
<td>23%</td>
</tr>
<tr>
<td>3.OA.7b - Divide numbers from 1-10</td>
<td>54%</td>
</tr>
<tr>
<td>3.NF.1 - Identify fractions and their parts</td>
<td>7%</td>
</tr>
<tr>
<td>3.NF.2 - Name fractions on a number line</td>
<td>11%</td>
</tr>
<tr>
<td>3.NF.3d - Compare fractions with the name</td>
<td>11%</td>
</tr>
</tbody>
</table>

When compared to the fall scores, there is a significant decrease in the number of students not proficient in each of the seven readiness standards. Standard seven, comparing fractions with the same numerator or denominator, showed the largest decrease of 65%. Standard five, identifying fractions and their parts, showed the least amount of decrease at 18% from fall to spring.

As the participants reviewed these results, the math consultant asked the teachers to reflect on what they did in order to achieve these results. The teachers cited the following actions: faithfully following the Delta Math program and making time every day for intervention; utilizing the calendar to map out time for each readiness standard; and utilizing the data to determine what the students needed. The math consultant then went on to ask the participants how they grew as an educator over the course of the year. The teachers cited the following areas of growth: tried new things; released control to students; gained a greater understanding of the standards; and taught new math content.
The table below shows the results from the fifth grade readiness screener. Notice that this screener was only given in the winter and spring.

Table 6

Results from the Spring 2019 Delta Math 5th Grade Readiness Screener

<table>
<thead>
<tr>
<th>Common Core Delta Math Readiness Standards</th>
<th>Percent of Students Below Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.NBT.5 - Multiply multi-digit numbers</td>
<td>31%</td>
</tr>
<tr>
<td>4.NBT.6 - Divide up to a four-digit number by a one digit number</td>
<td>38%</td>
</tr>
<tr>
<td>4.NF.2 - Compare two fractions</td>
<td>16%</td>
</tr>
<tr>
<td>4.NF.3b - Convert between improper fractions and mixed numbers</td>
<td>49%</td>
</tr>
<tr>
<td>4.NF.3c - Add and subtract mixed numbers</td>
<td>49%</td>
</tr>
<tr>
<td>4.NF.4b - Multiply a whole number by a fraction</td>
<td>24%</td>
</tr>
</tbody>
</table>

The purpose of this screener is to assess current grade level progress. When compared to the winter scores, there is a significant decrease in the number of students not proficient in each of the seven readiness standards. Standard two, divide up to a four-digit number by a one digit number, showed the largest decrease of 65%. Standard three, compare two fractions, showed the least amount of decrease at 16% from winter to spring. As the teachers reviewed this data set, the math consultant asked them what they wanted to focus on moving forward. Teacher W expressed how the lack of fact knowledge amongst her students was incredibly frustrating. Additionally, the resources they currently possess do not support fact fluency. The consultant tried to share with them some new fluency resources; however, they quickly ran out of time, and the meeting came to an end.
Spring Data Review Follow-Up Interview: Teacher W

Once again, Teacher W believes that the data obtained from both the fourth grade and fifth grade readiness screeners was an accurate reflection of her students’ skills. However, she was disappointed that some scores decreased from winter to spring on the fourth grade readiness screener. This decrease in scores made Teacher W question whether or not the students had truly obtained mastery in the winter. To help ensure mastery next year, Teacher W explained that she will utilize the Delta Math quick checks more frequently.

Teacher W also discussed how the data obtained from Delta was immediate, and, therefore, actionable. Unlike M-STEP, which Teacher W considers “dead data,” Delta Math told her exactly what she needed to do in order to move forward. Specifically, the data obtained from the fifth grade readiness screener in the winter empowered her to make decisions about the pacing of core instruction. As a result, she was able to cover specific content that she had not covered in the past. Interestingly, in deciding how to deliver the new content, Teacher W first reviewed the Delta Math strategies and, in many cases, preferred them over those presented in the district adopted text, Go Math! Her decision to change pacing was further supported by the growth in scores from winter to spring on the fifth grade readiness screener. Not only did the data from the screener support her in adjusting her pacing, it also helped her better understand why students struggled when new content was introduced.

Because of Delta Math, Teacher W engaged in the practice of intervention very differently than in years past. According to Teacher W, before this school year, she had never allocated time for math intervention. Additionally, the use of the lessons and manipulatives provided by Delta Math were unfamiliar to her. Teacher W explained that while she had engaged in some small group instruction in the past, her groups were never targeted on a specific skill,
like comparing fractions. Additionally, she did very little reteaching of concepts. If her class did poorly on a unit assessment, she quickly reflected on her teaching but then moved on to the next chapter in the text. Overall, the screener gave her clear direction, and the lessons allowed her to organize her intervention.

It is interesting to note that while protected time was provided for intervention, according to Teacher W, the utilization of that time was not necessarily monitored by the building administrator. As such, a teacher could have made the decision not to provide intervention. However, because her class was so academically low, she knew she had to provide intervention, but she wasn’t sure how to go about doing this work. According to Teacher W, Delta Math gave her the resources and the “how.” Teacher W hopes that other colleagues in her school will see the results of the fourth grade class and make the choice to better engage in the recommendations from Delta Math.

When asked to reflect on this year as a whole, Teacher W noted that this was one of the more difficult of her career. As previously mentioned, her students faced both behavioral and academic challenges. However, this was the perfect year to initiate Delta because it gave her the support and guidance necessary to address those challenges in mathematics. Teacher W explained,

Delta was a great experience. I loved the organization. I love the quick checks. I love the kids being responsible for their own learning and their own progress, and actually seeing that happen because they did. And it was nice to let them find success, because I don't feel like they really have had much success. So, you could see the look on their faces when they actually understood it, and they could see themselves understanding it.
Spring Data Review Follow-Up Interview: Teacher K

Overall, Teacher K found all three screeners to be a good measure of her students’ skills because the screeners measured the basic concepts in mathematics that all students need to know. Additionally, the outcomes of this screener matched her expectations. Unlike her colleagues, Teacher K has a 4th/5th split; therefore, she administered the fourth grade readiness, the fifth grade readiness and the sixth grade readiness screeners to all of her students. With regards to the fourth grade readiness screener, Teacher K noticed that students were still struggling with the timed facts for division. She noted that they “knew” their facts, but they just couldn’t complete them in the required minute. Regarding the fifth and sixth grade readiness screeners, Teacher K explained that many students were not at benchmark because she had not taught all the content assessed in the screener.

Teacher K finds the data obtained from the screener to be helpful because it allows her to be more intentional with small-group instruction. She can focus on specific skills with specific students. Not only did the data support her in her grouping, the data prompted her to focus on the Delta Math Readiness standards when planning for core instruction. Interestingly, Teacher K made the instructional decision to place less of an emphasis on the Go Math! text. She also shared that because she was given very little guidance on how she should teach the 4th/5th split, and because she had the support of the math consultant, it just “made more sense” to focus on the readiness standards embedded in the three screeners. Additionally, it was more manageable for Teacher K to focus on those skills instead of the 12 chapters present in the Go Math! series for both fourth and fifth grades.
As Teacher K reflected on how much her teaching of mathematics had changed over the course of the 18-19 school year, I asked her what variable most impacted her change. Teacher K responded:

Yeah, I would say it was probably knowing that we were going to be meeting with you. I've been handed lots of data before, unfortunately, and I was never... it changed, unfortunately. I mean, it does... it puts you in a different mode when you have to meet and discuss it and things like that. I just think it's... and teachers don't like that, but that is what causes the change, I feel like.

So often teachers are provided data, but there isn’t always follow-up on how that data is being utilized to guide instruction. In this case, Teacher K intentionally utilized the provided data because she knew that she would be asked to reflect and discuss how she responded to the data with myself and the math consultant.

Moving forward, Teacher K is looking forward to employing all the skills she learned this year independently. She believes she now has a system that will allow her to better respond to the needs of her students.

**Spring Data Review Follow-Up Interview: Teacher S**

Once again, Teacher S agreed that the data obtained from both the Delta Math fourth and fifth grade readiness screeners was a valid measure of her students’ skills. Throughout this interview, Teacher S indicated a variety of instructional changes that occurred throughout the school year. These changes include more frequent interventions; more intentional grouping; more standards-driven; adjustments to pacing; engaging in new content; and changing delivery. Before Delta Math, Teacher S would only group students after the completion of a unit test from their core math text, Go Math! As a result, she was only pulling students once every three weeks.
Additionally, what she focuses on during small-group instruction is much more targeted. Before, a small group might focus on a variety of skills from a unit assessment. Now, her groups are focused on specific standards.

Teacher S also noted that she has become more standards-driven. She explained that before Delta Math, she would just go through the motions of teaching from her Go Math! text without much regard to the standards. Now she looks at the standards, specifically the fifth grade readiness, and makes strategic selections on what lessons to focus on within Go Math! This, in turn, has had a direct impact on her pacing. Before Delta Math, there were some critical fourth grade standards Teacher S was never able to get to. However, this year she was able to better make decisions about how long to spend on a particular standard in order to address more content. While she wasn’t able to cover all of the fifth grade readiness standards, progress was made. Interestingly, she utilized the Delta Math lessons to teach the new content. Finally, not only did Delta have an impact on her pacing and instruction, it also supported her understanding of the standards. Now the standards guide her instruction. If students are not proficient with a given standard, she will utilize small groups to better facilitate their understanding.

**Chapter 4 Closure**

The data in this study was collected by 12 semi-structured interviews and three observations of three fourth grade teachers from an elementary school in southwestern Michigan. Overall, the teachers found the data obtained the Delta Math readiness screeners to be an accurate reflection of their students’ skills in mathematics. Additionally, the teachers utilized the data and lessons from Delta Math to elevate both their intervention block and core instruction. Over the course of the 2018-2019 school year, the number of students reaching benchmark on the fourth grade and fifth grade readiness increased, despite their reputation for being
academically and behaviorally difficult. In the next chapter, I will provide in-depth answers to each of the research questions for each participant. Specifically, I will investigate the mental models that were applied to the various data sets and how those models changed over time. Finally, I will provide a rich description of the various instructional changes that were made by the participants during the study. A cross-case analysis will also be provided, along with a discussion of next steps of policy implications.
CHAPTER V
FINDINGS WITHIN THE CASE AND ACROSS THE CASES

In this chapter, I will provide in-depth answers to each of the research questions for each participant. Specifically, I will investigate the mental models that were applied to the various data sets and how those models changed over time. Finally, I will provide a rich description of the various instructional changes that were made by the participants during the study. A cross-case analysis will also be provided.

Major Results as Connected to the Research Questions for Teacher W

Research Question 1

Research question one is as follows: What types of mental models are applied during sensemaking within the Delta Math RTI Program data cycle? In the initial interview, Teacher W applied mental models one, three and four. Model one, instruction, can be seen when she states:

So if I give a quiz that half the class bombs, I have to re-teach it. I didn't do something right. You know. I have to go back, re-think what I did, and find a way for them to understand it. So that's the most reflective on me personally, not as in a grade level, not as a district, on me.

She goes on to explain:

You know, there's some things, some variables, sometimes that you can't really control. But 99.9%, you know, is coming from my instruction. Did I teach it well enough, did I find the right method, did I give them the right model, or not?

This comment reveals that Teacher W takes ownership and responsibility for her instruction. After she reviews achievement data, she considers the steps necessary to meet the needs of her
students. Teacher W believes her locus of control is internal, and the outcome is not stable. However, the outcome is controllable via her instruction.

With regard to model three, nature of the test, Teacher W shared this experience with the state assessment M-STEP:

Man, wording is just huge for me. Because I've seen things worded so many different ways. Wording, strategies ... I don't like the M-STEP at all. I mean, it's on a computer. Their computer knowledge, you know, that's huge. The way they can use the tools on the computer, the way ... if they have to scroll down on the computer. I mean it's all the little things. I don't think it's always necessarily their true assessment if they know how to do the math or not. Their reading ability ... There's so much reading on the M-STEP. And kids that can't read can still do math.

In this case, Teacher W does not have a role in the creation of the M-STEP. As such, the locus of control will be external, and the outcome will be uncontrollably stable. Because the M-Step requires students to solve word problems, Teacher W does not believe that the data obtained from this assessment accurately assesses the math skills of her students. If a child struggles with reading, then the results will not identify what specific math concepts are lacking. Additionally, Teacher W believes that because this assessment is on the computer, a student’s ability to correctly navigate the technology could be a barrier in assessing their true math knowledge. Recall that the application of this model does not necessarily yield a change in instruction.

Finally, Teacher W’s application of model four, student attributes, is realized in the following:

I will be honest this year that we have very low academic group, very low. I believe a lot of intervention and modification is going to have to take place within that core,
whole group instruction, as well. Just because of ... they're really missing a lot of pieces. But there's so many other factors that go into it, especially in a low income district like ours. And I don't want to make excuses because that's not what I'm doing. We don't all live cookie-cutter lives.

Here Teacher W expresses her preconceived notions of her students. In applying Model 4, Teacher W perceives the cause of student outcomes to be inherent student characteristics. These characteristics could include low socio-economic status, emotional or cognitive impairments. In this case, her fourth grade class is academically low. Attribution to student characteristics could undermine motivation to adjust instruction for Teacher W because it involves an external locus of causality, stability, and uncontrollability.

After screening her students on the fall Delta Math screener, Teacher W applied models 1, 2, and 4 to this initial data set. The application of model one is revealed when she explains, “It (Delta) showed me the holes that I needed to fill in to get them ready for fourth grade curriculum.” In this instance, Teacher W believes she has control of her instruction and can have a positive impact on student understanding.

Her application of Model 2, student understanding, becomes apparent in the following comment when she states:

So, since I've seen so much progress and the kids actually love that time of day when we do these, that just drives my instruction in wanting to use it more. It's working. They love the quick checks. They love graphing it. They love how it flows and that it's quick. They love using the manipulatives because pretty much every lesson has that. They really like it.

She goes on to explain, “There's a lot of problems, and there's been a lot of changes. It's going
great. It really is. They've really changed a lot. They've really turned things around.”

In this case, Teacher W noticed that student understanding can change over time. Students are responding well to the interventions and making progress. Both Teacher W and the students are excited about the changes that have been made.

Finally, Teacher W applies Model 4 when she explains:

I mean, plain and simply, a horrible reputation, I mean, from kindergarten. Oh, wait until you get them. First grade, oh, wait until you get them. Second grade, you know, on and on and on. They haven't had the best time in school. They didn't like school. They got in trouble constantly.

Once again, Teacher W explains how this class has always had a reputation for being a difficult group. However, her application of this model did not prevent her engaging in instructional change.

Upon the conclusion of the winter screening, Teacher W predominantly applied models 1 and 4 to the Delta Math Screener results. Here again we see that she believes that her instruction has an impact on student achievement; however, she also believes that student attributes are having an adverse effect on the data. Interestingly, she applies model one to the Winter 4th Grade Readiness screener and model four, student attributes, to the Winter 5th Grade Readiness screener. When asked if the data from the 4th Grade Readiness was a good measure of her student’s skills, she replied:

I would say this screener ... yes, it was helpful. I loved seeing it. There was huge growth I was really happy with, but as the first screener is, I think, the more helpful because that's where you have to really dig deep and say what interventions do I need to
make, what groups do I need to create, what lessons do I need to create [inaudible 00:03:58].

She then goes on to explain that the screener allows her to reflect on next steps, specifically, “Okay, where do I need to go? What do I need to do? What should I hit? What do I need to go back to even though we weren't really far enough to go back to anything.” This quote clearly indicates the participant’s acknowledgement that her instruction has an impact on the outcomes obtained from the screener. Additionally, it demonstrates the instructional changes she will utilize in response to the data.

Moving on, when Teacher W was asked if the data from the 5th Grade Readiness was a good measure of her student’s skills, she replied:

Yes, it's definitely a good measure of my students' skills. The scores were low, and that didn't surprise me. This group was low coming into fourth grade, so we really had to hit those third grade standards hard, which we did, but they're just going to be a little bit behind this year is the easiest way to put it. I was frustrated for sure, but it was accurate.

She goes on to explain,

I'm really frustrated in the level that these kids came to me at, and how far we're behind because of that. We had to do so much backtracking with these kids that the fourth grade standards are ... we're not anywhere near what our pacing guide says we should be, and it just bothers me that we had to do that.

A potential fifth model, nature of prior instruction, also seems to emerge here. As her transcript highlights, she has concerns with the instruction and expectations of prior teachers. Specifically, Teacher W states:

We have said the must have, the must have, the must have, but you have to have
follow through. You have to have accountability for that, and there isn't any. We've talked about it, we've made lists for it, there's lots of things in place except accountability. This year has been the most frustrating so far, and this is my third year in fourth grade. It's been the most frustrating because they're just ... I just feel like these kids in particular have been given up on. They're a tough group. But we've made so much growth, and it's just sad the place they're in.

She goes on to explain:

I just wish this was in place last year, and like I did with the accountability. Yeah, it's in place this year, but I feel like maybe our team's the only one that's really being held accountable with it, and that's through you. I hope the other grades are doing it like they're supposed to because it works. I'll show you it works.

According to Teacher W, because her colleagues have not been held accountable for delivering a guaranteed and viable curriculum, her students are now at an academic disadvantage. This has caused her great personal frustration throughout this particular school year. While this may be related to Model 4, student attributes, it is also connected to her beliefs about the quality of prior instruction. At the time that I conducted my review of the literature, this phenomenon was not present in the research.

Finally, in the spring, Teacher W predominantly applied models one and two to the Delta Math Screener results. She believes that her instruction has an impact on student achievement. She finds the data actionable and feels confident in responding to the results. She also believes that student understanding can change over time. She noticed a dip in scores from winter to spring and questioned winter mastery. However, instead of attributing this outcome to student
characteristics, she believes she can avoid this outcome in the future by intentionally reviewing the fourth grade readiness skills throughout the year.

**Research Question 2**

Research question two is as follows: How do these mental models change over the course of the school year? In Table 7 below we see how Teacher W’s mental models changed throughout the course of the 18-19 school year. Consistently she applied model one to each Delta Math data set. Recall that models one and two are associated with changes in instruction while models three and four are not associated with changes in instruction. Teacher W’s application of models not associated with instructional change ceased after the spring data review.

Table 7

*Teacher W’s Application of Mental Models During the 18-19 School Year*

<table>
<thead>
<tr>
<th>October 2018</th>
<th>November 2018</th>
<th>February 2019</th>
<th>June 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Interview</td>
<td>Fall Data Review</td>
<td>Winter Data Review</td>
<td>Spring Data Review</td>
</tr>
<tr>
<td>Follow-Up Interview</td>
<td>Follow-Up Interview</td>
<td>Follow-Up Interview</td>
<td>Follow-Up Interview</td>
</tr>
<tr>
<td>1. Instruction</td>
<td>1. Instruction</td>
<td>1. Instruction</td>
<td>1. Instruction</td>
</tr>
<tr>
<td>3. Nature of the Test</td>
<td>2. Student understanding</td>
<td>4. Student Characteristics</td>
<td>2. Student understanding</td>
</tr>
</tbody>
</table>
Research Question 3

Research question three is as follows: What type of instructional changes results from the application of these mental models? Careful analysis of Teacher W’s initial interview reveals that she typically engages in the following instructional changes: reteaching and grouping. The following explanation best captures these instructional changes:

Yeah. Absolutely. Anybody that doesn't do well will definitely get some sort of re-teaching. It doesn't have to be ... I don't look at it as, okay, if half the class didn't get it, then I'm going to re-teach it. Any student in my class at all that doesn't get a C or higher, I re-teach with. I don't wait until they're not doing well in the class. You know, it's immediate. So my assessments will immediately affect their outcomes.

Here it becomes readily apparent that Teacher W will reteach concepts in both whole-group and small-group settings. Additionally, she works with all students to ensure that they have mastered the intended skills.

After analyzing the data obtained from the Fall Delta Math screener, Teacher K engaged in the following instructional changes: grouping, student reflection, and change in delivery. In reference to grouping, Teacher W explained:

When I was going into the intervention with these kids, we decided to do whole group intervention instead of small groups. If there was a certain percentage or above that didn't meet the standard, he (the math consultant) advised us to do whole group instead because there were just too many of them to do small groups.

Careful analysis of this quote reveals that Teacher W utilized the data obtained from the Delta Math Readiness screener to determine whether a skill should be taught either whole or small group during WINN time. In this case, the data indicated that the majority of students did not
understand a particular concept. As such, conducting small groups would not have been efficient. Typically, small-group instruction is employed in this setting; however, in this case the data indicated that a whole-group intervention would be more appropriate.

With regard to student reflection, Teacher W shared this experience: “They really like it, and they really like seeing their progress when you do those quick checks, and they get to graph their progress and see that, okay, I didn't understand it and now I do.”

She then went on to explain:

We decided to do that, and then the lessons that go with each readiness standard, they come in eight parts, and they basically show four different ways twice of how to reteach those lessons, which they're not necessarily things that I have done before. Some of them even breaking it down into like 10 frames, not quite as low as what I'm used to going with fourth graders, but just showing them several ways, different ways, to do different types of problems. We're on the third readiness standard now, so there's been a lot of different ways that we've retaught adding, subtracting, and multiplying.

Here Teacher W is noting a change in delivery. Specifically, she is utilizing the Delta Math lessons to provide students with new strategies for solving problems. Strategies, like 10 frames, are new to Teacher W.

Finally, Teacher W engages in an instructional change that is not readily apparent in the literature. In this case, Delta math empowers her to strategically plan both the content and progression of WINN time. Teacher W explains:

Oh, it's definitely helpful. It completely changed my...well, it guided my WINN timed instruction. “What I Need” is what we call it, our WINN time. We do it for math and that's new this year, and I didn't really know where to start. So, that gave me basically
my exact curriculum that I'm following with the lessons because we are using the Delta lessons along with the screener and the quick checks, and it's my entire WINN curriculum for my class.

After analyzing the data obtained from the Winter Delta Math screeners, Teacher W engaged in the following instructional changes: reteaching, regrouping and student reflection. The results from the screener supported her in forming groups and provided her guidance on what concepts to reteach. With regard to student reflection, Teacher W shared this experience:

Using those quick checks were huge, so huge. My kids loved them. They loved tracking their progress. They loved having a goal. They loved meeting that goal. They understood that sometimes they didn't need it. Sometimes you'd have a bad day, and I had to teach them that you could do that. You could move on. But those quick checks and the binders we created for that were fabulous. I will use them forever.

Here Teacher W explains how the quick checks provided by Delta Math had a positive impact on both her students and her instruction; so much so, that she intends to continue utilizing them in the future.

Also during this interview, an instructional change occurred that was not identified in the initial review of the literature. Specifically, Teacher W considered only focusing on the Delta Math fifth grade readiness standards for the remainder of the school year. Because she is behind on her fourth grade scope and sequence, she feels a need to prioritize content based on the readiness standards assessed in the fifth grade. According to Teacher W,

I don't want to say that it's changing my instruction, but I feel like it's probably driving where I'm going in my instruction because I might only really hit the readiness standard in my curriculum because of the time frame. Then, that leaves some stuff left undone,
unfortunately, but it's basically 10, 11, 12 weeks left, whatever it is. There's only so
much time, and I feel like the readiness standards will drive where I'm going. Then,
hopefully, I'll have enough time to go back and hit more, but I feel like that's what I'm
going to really focus on. Then, (I will) also use that for intervention when I'm done with
that chapter. Does that make sense?

Teacher W’s insights reveal that she will utilize the standards from the Delta Math fifth grade
screener to prioritize what content she will focus on for the remainder of the school year.

*Figure 6* below lists the standards Teacher W intends to plan her instruction around.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.NBT.5</td>
<td>Multiply multi-digit numbers</td>
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<td>4.NBT.6</td>
<td>Divide up to a four-digit number by a one digit number</td>
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<td>4.NF.2</td>
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<tr>
<td>4.NF.3b</td>
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</tr>
<tr>
<td>4.NF.3c</td>
<td>Add and subtract mixed numbers</td>
</tr>
<tr>
<td>4.NF.4b</td>
<td>Multiply a whole number by a fraction</td>
</tr>
</tbody>
</table>

*Figure 6. Delta Math readiness standards*

After analyzing the data obtained from the Spring Delta Math screeners, Teacher W
engaged in the following instructional changes: grouping, change in delivery and student
reflection. The results from the screener supported her in forming groups and gave her feedback
regarding what skills needed to be retaught. While Teacher W utilized small group instruction in
the past, it was never targeted on a specific skill. Additionally, this was the first time she
allocated time specifically for intervention. Her students’ historically low achievement prompted
her to make this time a priority. While protected intervention time was a requirement at her
school, it was not monitored. Therefore, at any point in the year she could have decided to stop the intervention block.

A change in delivery was supported by lessons and manipulatives provided by Delta Math. As for student reflection, the quick checks allowed students to chart their progress. Teacher W noted how this motivated her students and allowed them to experience success. This, in turn, encouraged her to continue utilizing the Delta Math lessons.

During this last interview, new potential instructional changes not articulated in the literature emerged. Specifically, Teacher W made some intentional changes to her scope and sequence. Utilizing the fifth grade readiness standards from Delta Math, she focused her instruction on these concepts and “unofficially” abandoned the district-created pacing guide and cut content. Teacher W explained:

Some of the things, and I talked about this in our data day when we talked about this, was that in fourth grade I didn't necessarily teach some of those readiness skills at all because I never got to it. So I liked that it showed me in the winter [inaudible 00:04:24] we gave it. And then in the spring how much growth was made because of the direction I decided to take . . .

As a result of this decision, she was able to cover concepts related to fractions that she had not been able to in prior years. In planning for these new concepts, she first reviewed the strategies presented in the Delta Math lessons before reviewing those in Go Math! In many instances, she preferred the strategies in Delta Math and utilized those over those in Go Math!

A summary of the instructional changes employed by Teacher W are summarized in
Table 8 below.

Table 8

*Instructional Changes employed by Teacher W During the 18-19 School Year*

<table>
<thead>
<tr>
<th>October 2018</th>
<th>November 2018</th>
<th>February 2019</th>
<th>June 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Interview</td>
<td>Fall Data Review</td>
<td>Winter Data Review</td>
<td>Spring Data Review</td>
</tr>
<tr>
<td>Instructional Changes Employed</td>
<td>Instructional Changes Employed</td>
<td>Instructional Changes Employed</td>
<td>Instructional Changes Employed</td>
</tr>
<tr>
<td>2. Grouping</td>
<td>2. Grouping</td>
<td>2. Grouping</td>
<td>2. Change in Delivery</td>
</tr>
<tr>
<td>3. Change in Delivery</td>
<td>3. Change in Delivery</td>
<td>4. Student Reflection</td>
<td>3. Student Reflection</td>
</tr>
<tr>
<td>4. Student Reflection</td>
<td>4. Reprioritization of content</td>
<td>5. Reprioritization of content</td>
<td></td>
</tr>
</tbody>
</table>

5. *Strategic Intervention Planning*

Here we see that over the course of the 18-19 school year, Teacher W employed six different instructional strategies in response to the data obtained from the Delta Math screeners. Of the strategies employed, two were not readily apparent in the review of the literature. These strategies, italicized in the table above, include; strategic intervention planning and reprioritization of content. Of those present in the literature, she employed grouping, reteaching, student reflection and change in delivery throughout the year.
Major Results as Connected to the Research Questions for Teacher K

Research Question 1

Research question one is as follows: What types of mental models are applied during sensemaking within the Delta Math RTI Program data cycle? In the initial interview, Teacher K applied mental models one, two and four. Model one, instruction, can be seen when she states:

“I feel like I have an integral role, I'm the one that's in front of the teacher, in front of the students teaching and preparing them for the end of the year score.”

This comment reveals that Teacher K feels very strongly about her role in student achievement, she takes ownership and responsibility for her results. She then goes on to explain:

But if I saw some or a large majority of the students doing poorly, I would take a look at how I was presenting it and looking at, okay, what was our problem? Was it actually the skill or strategy, was it vocabulary that held us up. What was it?

This explanation also indicates the application of Model 2, student understanding. Teacher K’s utilization of the word “our” indicates her acknowledgement of student understanding and its impact on achievement data. While she considers her presentation of the content, she also reflects on how student misconceptions, specifically around strategies and vocabulary, can impact results.

Finally, with regard to Model 4, student attributes, Teacher K does note student attendance as a factor impacts results on various assessments. In her interview she states, “I would say attendance because if they’ve missed a lot, they're probably not going to do as well.”

After screening her students on the fall Delta Math screener, Teacher K again exhibited mental models 1 and 2. This application of these models is revealed when she explains:

And that, hopefully, I'm teaching them how to be more accurate and to double check
their work so that we aren't making as many silly mistakes because I honestly think some of them could've been higher if they had fine-tuned that checking strategy in the beginning.

In this instance, Teacher K believes that by modeling for students’ strategies that allow them to check their work, they can be empowered to improve their outcomes. Teacher K has control of her instruction and believes that student understanding can change over time.

Upon the conclusion of the winter screening, Teacher K once again exhibited mental models 1 and 2. “I think if I'm covering things well, and they take what I've taught them and take those strengths to go forward, I think everything will be okay.” She also explains how when she facilitated small group instruction, she asked individual students what they don’t understand and uncovered that, in some instances, it’s not the conceptual understanding of the concept but rather a lack of fact knowledge.

Finally, in the spring, Teacher K continues to apply mental models 1 and 2. The results from the screener are in alignment with her expectations, and she explains: “I hadn't gotten enough of the teaching in before we assessed it; otherwise, I think they'd have done just as well on that.” In this instance, Teacher K accepts responsibility for lower scores because she knows she was not able to teach that specific content. Additionally, she believes that if her students had access to that information, they would have done better on the assessment.

Careful analysis of Teacher K’s interviews reveal that she consistently applied models one and two to the various data sets. Furthermore, there was only one application of model four, and there was no application of Model 3, nature of the test.
Research Question 2

Research question two is as follows: How do these mental models change over the course of the school year? In Table 9 below we see that Teacher K’s mental models remained relatively fixed throughout the course of the 18-19 school year. Consistently she applied models 1 and 2 to each Delta Math data set. Recall that models 1 and 2 are associated with changes in instruction while models three and four are not associated with changes in instruction. Interestingly, she did apply mental Model 4 in her initial interview; however, it was never applied again. Additionally, she never applied Model 3, nature of instruction, to any data set.

Table 9

Teacher K’s Application of Mental Models During the 18-19 School Year

<table>
<thead>
<tr>
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</tr>
<tr>
<td>1. Instruction</td>
<td>1. Instruction</td>
<td>1. Instruction</td>
<td>1. Instruction</td>
</tr>
<tr>
<td>2. Student understanding</td>
<td>2. Student understanding</td>
<td>2. Student understanding</td>
<td>2. Student understanding</td>
</tr>
<tr>
<td>4. Student Characteristics</td>
<td></td>
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</tr>
</tbody>
</table>

Research Question 3

Research question three is as follows: What type of instructional changes result from the application of these mental models? Careful analysis of Teacher K’s initial interview reveals that
she typically engages in the following instructional changes: reteaching, change in delivery, grouping, and student reflection. The following explanation best captures these changes:

What I've done most of my teaching career is, on top of the direct instruction and games, I would make even smaller groups to pull, so I can more easily view what it is that they're doing in front of me and where our mistakes are coming from. So if we were, if I thought we had a good grasp of division and I gave a division test, and it came back that they did very poorly, I would need to look at, okay, what exactly are we doing wrong, and I would make smaller groups so that I could focus on just three or four kids at a time instead of (the) whole group.

After analyzing the data obtained from the fall Delta Math screener, Teacher K engaged in the following instructional changes: grouping and change in delivery. Regarding a change in delivery, Teacher K explained, “So I guess those are the ways that I've changed is I'm focusing on many different strategies and ways instead of the same strategy over and over and over.”

When asked to describe a new strategy that she employed, she related the following insight:

I've used the base 10 blocks before, having the kids manipulate them and stuff, but I've never had them draw them. And I think that helped a lot with them understanding. And then I would show them how that correlated to the crossing out, because some of them just thought, like, "When I start crossing out, I just cross out across the whole way …

Note that this strategy was presented via one of the Delta Math lessons for multi-digit subtraction.

With regard to grouping, Teacher K explains how she made the instructional change to group her students instead of teaching them as a whole group for core instruction. Teacher K stated: “And in my regular core, having them separated, but then also bringing them together to
share on the things that they're learning so that it's just making it more cohesive and makes it come together better, I guess.”

After analyzing the data obtained from the Winter Delta Math screeners, Teacher K engaged in the following instructional changes: reteaching and grouping. Teacher K relates the following insights:

Yes, because it shows me where to focus. I noticed that there were areas that I don't need to continue to go over, I just throw them in as a review every once in awhile. Plus, I like the fact that, and that's what I'm doing this next week, going forward, I took the data and I went to, it'll automatically put the kids in their prevention groups based on the percentage of people who scored below the benchmark. So just allowing me, it gives the group the focus on, ‘Okay, let me see what it is they don't understand.’ This quote reveals that the data from the screeners allowed Teacher K to make decisions about what content needed to be retaught. Specifically, it empowered her to move on from certain skills because students had obtained mastery. However, to ensure that students maintain mastery, she continued to review the skills from the readiness screeners when appropriate. For students who had not obtained mastery, she utilized small group instruction targeted to specific skills identified on the screener.

Also, during this interview, instructional changes occurred that weren’t identified in the initial review of the literature. These changes included reprioritization of content and aligning tier one and tier two content. As regards reprioritizing content, Teacher K related this insight:

I looked at what we were lacking in the most, and we were talking about how we really need to get to fractions and we really need to get to dividing. That's what I'm really focusing on before spring break here; the whole month of March is fractions and
division.

She goes on to further explain:

I was like, these power standards that I have to get, it's like, ‘Do I get to the power standards? Do I get to?’ You know, I kind of put the things that are in Delta as a priority. Yeah, I feel like if we can get those in place, they shouldn't be lacking in much.

In this case, Teacher K noticed that if she was going to address the readiness standards, see Figure 7, it would be critical for her to shift her focus to only these standards.

<table>
<thead>
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<td>4.NF.4b</td>
<td>Multiply a whole number by a fraction</td>
</tr>
</tbody>
</table>

*Figure 7. Delta Math fifth grade readiness standards.*

In regard to aligning Tier 1 and Tier 2 content, Teacher K noted:

So I was teaching different skills than what we're necessarily going over in our math WINN with Delta. I decided to match them up. So what they're doing in the curriculum right now, fourth grade is doing division, they're just doing easier division. Fifth grade's doing division, and in math WINN, we're doing division. So I'm just hitting it more all around.

She goes on to explain:
Whereas before, I was teaching like, for example, fourth grade would be doing area and perimeter, and for Delta WINN, we were doing multiplying multi-digit numbers, or fractions on a number line or something. It may or may not have gone hand-in-hand; now it's altogether.

Here Teacher K is trying to align the skills she is teaching during core instruction with the skills she is teaching during her intervention block. For example, after analyzing the data obtained from the Spring Delta Math screeners, Teacher K engaged in the following instructional changes: reteaching and grouping. The following best captures these changes:

I would say the small groups, I utilized the intervention groups. I went back and reviewed quite frequently, and I don't know why I don't do that [inaudible 00:18:25] did that, I mean, because I just, like I said, I felt like those are the important foundational skills. And so what I did, I kept reviewing them versus normally, I would teach something, move on, teach that, move on. So I kept circling back on my own just because they were quick checks, and you could do it quickly. And I mean, I didn't even need a quick check. I could just give them two or three problems.

Finally, this interview revealed an instructional change that was not readily apparent in the review of the literature. Specifically, because Teacher K saw the Delta Math standards as essential for mathematical success, she began to favor Delta lessons over the district-adopted text Go Math! Teacher K relates this insight:

Yes. I use my Delta resources more than my Go Math! resources. I think because we even sat down with J. and did the schedule and the mapping of and pacing out the skills for Delta. I think what I would do next year if I were to go forward with this is to sit
down and then look at the units and make sure the unit that I'm teaching integrates well with the Delta skill that I'm teaching that week, so that they are more in conjunction rather than separate entities.

She goes on to explain:

And so I think because I didn't have very much clarification, and I do feel like Delta's skills are a good basic foundation and building block. I just decided... and because we had J’s assistance and we planned it out really well, I think I just decided to go with that. It just made more sense to me.

Finally, Teacher K concludes: “I tied in as much as I could to the core. I didn't do as much from Go Math! I kind of relied heavily on the Delta because I really feel like Delta has the skills that they need.” A summary of the instructional changes employed by Teacher K are summarized in Table 10 below.
Here we see that over the course of the 18-19 school year, Teacher K employed seven different instructional strategies in response to the data obtained from the Delta Math screeners. Of the strategies employed, three were not readily apparent in the review of the literature. These strategies, italicized in Table 10 above, include reprioritization and realignment of content. Of those present in the literature, she predominantly employed grouping and reteaching, while student reflection was only noted in the initial interview.
Major Results as Connected to the Research Questions for Teacher S

Research Question 1

Research question one is as follows: What types of mental models are applied during sensemaking within the Delta Math RTI Program data cycle? In the initial interview, Teacher S applied mental models one, three and four. Model one, instruction, can be seen when she states:

But I just really want to know where they're at, and then I'll start diving into my [gold 00:14:00] math, what sections I need to teach, thinking of those power standards, making sure I hit all of them. Just, I want to know where they are and where I can go from here.

She goes on to explain:

So, it's just hopefully that I prepared them enough to take this quiz hoping for the results that I want to see, or so I know what they're working on and what I need to continue working on, reteach, review, move on, kind of tell me where I'm at.

This comment reveals that Teacher S takes ownership and responsibility for her instruction. After she reviews achievement data, she considers the steps necessary to meet the needs of her students. Teacher S believes her locus of control is internal, and the outcome is not stable. However, the outcome is controllable via her instruction.

With regard to model three, nature of the test, Teacher S shared this experience:

Well, unfortunately, I do not love M-STEP, only because, to me, it seems like that data, they take the test and then we don't find results, well, Mr. (the name omitted to ensure anonymity) does give us like raw scores, but you don't get the overall scores. It still has the word problems left that they still have to grade, or whatever. But it just depends on the day really. I mean, the problem with the math is a lot of times it's just word
problems, so if the students can't read, they could possibly get the problem wrong if they're not really reading into those problems. So, it's just hard for me because I just feel like it's that data that we don't, we don't get that data back to really hone in on those skills that demands math.

In this case, Teacher S does not have a role in the creation of the M-Step. As such, the locus of control will be external, and the outcome will be uncontrollably stable. Because the M-STEP requires students to solve word problems, Teacher S does not believe that the data obtained from this assessment will accurately assesses the math skills of her students. If a child struggles with reading, then the results will not identify what specific math concepts are lacking. Recall that the application of this model does not necessarily yield a change in instruction.

Finally, Teacher S’s application of Model 4, student attributes, is realized in the following:

Yeah. I do know that this group is extremely low. I knew that before they came in, but I wanted to give the students the benefit of the doubt that maybe the teachers were bored, just maybe weren't as pleased with the group. But, unfortunately, they are really low.

Here Teacher S expresses her preconceived notions of her students. In applying Model 4, Teacher S perceives the cause of student outcomes to be inherent student characteristics. These characteristics could include low socio-economic status, emotional, or cognitive impairments. In this case, her class of fourth graders are academically low. Attribution to student characteristics could undermine motivation to adjust instruction for Teacher S because it involves an external locus of causality, stability, and uncontrollability.
Teacher S goes on to explain another student characteristic, confidence, which she believes also impacts assessment outcomes:

I think a lot of it comes from the confidence in that lesson. So, if we're working on, right now that [inaudible 00:14:48], some of my students just lack confidence because they truly do not understand what they're supposed to be doing. So I think a lot of it can come from the confidence. Again, just the unknown, like, ‘I don't know what I'm doing.’ Maybe they see others finishing before them, ‘Oh, I gotta [sic] hurry and finish to get this done, I don't want to be the last one working.’ So it's just like the daily structure and schedule of the classroom, I guess.

Here again Teacher S attributes outcomes to student confidence. It is interesting to note that attribution to student characteristics could undermine motivation to adjust her instruction because it involves an external locus of causality, stability, and uncontrollability.

After screening her students on the fall Delta Math screener, Teacher S applied all four mental models to this initial data set. The application of model one is revealed when she explains: “Delta Math is huge because it's showing those skills are missing, those third grade skills, so we can help fix those skills before moving on. I think this is a really, really good year for this.” In this instance, Teacher S believes she has control of her instruction and can have a positive impact on student understanding.

Her application of Model 2, student understanding, becomes apparent in the following comment when she states, “I think the summer slide because now looking through the folders, it's like, ‘Well you do know how to do it, but you had zero percent for addition.’ ” In this case, Teacher S notices that student understanding can change over time, particularly during the summer months.
With regard to Model 3, nature of the test, she notes, “Or transferring the data from the paper after they did it, their answer from the paper to the computer could have been another thing.” Because the Delta Math screener is on the computer, Teacher S believes that some of the outcomes may have occurred because some students couldn’t properly transfer their answers from paper to the computer screen.

Finally, Teacher S applies Model 4 when she explains:

I have the lowest class of the threes, and, at this point, it's like I know I need to get to these fourth grade standards, but I'm struggling with these basic skills they don't have. Like we have to be able to add; we have to be able to subtract.

She goes on to explain:

So when we first, we knew coming in this group was low; we all tried to ignore that.

And just think, ‘Ignore what you hear before and see what they can really do.’ After getting that Delta Math, it was an eye-opener, like, okay. Yeah, they really are this low.

Here the data from the screener confirmed for Teacher S that her students were not at grade level in mathematics.

Upon the conclusion of the winter screening, Teacher S once again exhibited mental models 1 and 2. Models 1 and 2 emerge when she states: “For the most part, yes, the kids, we have been working on those every day. We do the lessons with the quick checks. So, for the most part, I feel like the results were accurate.” This quote reveals that Teacher S believes that both her instruction and student understanding had an impact on the results from the teachers. Both she and her students have been working diligently through the lessons provided by Delta Math in an effort to improve their math skills. Note that this is the first interview where Teacher S does not apply a negative mental model.
Finally, in the spring, Teacher S applies only Mental Model 1. The results from the screener are in alignment with her expectations and she explains:

    So we taught them, went over them, reviewed them and then we took the test. So I think that for the most part, all of that is or showed exactly their capabilities… So, I would say that it’s pretty accurate, but if we could have had more time, they would have performed better.

In this instance, Teacher S accepts responsibility for lower scores because she knows she was able to teach that specific content. Additionally, she believes that if her students had access to that information, they would have done better on the assessment.

    Careful analysis of Teacher S’s interviews reveal that while she applied every model at some point in the study, she consistently applied Model 1 to the various data sets. Also, notice that her application of the negative models stopped upon the conclusion of the school year.

**Research Question 2**

    Research question two is as follows: How do these mental models change over the course of the school year? In *Table 11* below we see how Teacher S’s mental models changed throughout the course of the 18-19 school year. Consistently, she applied Model 1 to each Delta Math data set. Recall that models 1 and 2 are associated with changes in instruction while models 3 and 4 are not associated with changes in instruction. Interestingly, she consistently applied mental models associated with instructional change. However, her application of models not associated with instructional change ceased during the second semester of the 18-19 school year.
Table 11

*Teacher S’s Application of Mental Models During the 18-19 School Year*

<table>
<thead>
<tr>
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<td>1. Instruction</td>
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</tbody>
</table>

**Research Question 3**

Research question three is as follows: What type of instructional changes result from the application of these mental models? Careful analysis of Teacher S’s initial interview reveals that she typically engages in the instructional change of reteaching. The following explanation best captures this change:

Okay. First things first, grade it, and then I like to organize it by students who have mastered and got all, maybe all but one, all but two. And then look at the rest of the papers and figure out if there are certain problems that all of the students missed. Is it something that maybe I didn't teach well enough; I need to go back. Is it just random problems that maybe they weren't sure? I will look for any kind of pattern that tells me
that they didn't know it, that I didn't teach it well enough, you know, so I can reteach, so all students are understanding and mastering that skill.

Here we see that Teacher S will typically take the results of a classroom assessment and determine which concepts she will need to reteach with the entire class.

Interestingly, Teacher S also described an instructional change that was not readily apparent in the review of the literature. Specifically, she shared how she established a rewards system in order to potentially impact assessment outcomes. Teacher S related this experience:

Okay. In our class, fourth grade, we started with almost like an award system because a lot of the students do not take tests serious(ly). They don't really understand the value of the test, ‘whoop-de-do.’ But we did more of like a rewards system where, in Edmentum if you went up in one of the three areas, you receive a movie. You went up for two out of the three, you received a movie and popcorn. Then all three was [sic] movie, popcorn, pop. So they see that not only [inaudible 00:11:25] important that when you do try hard to get things in return. With the NWEA, which I feel would be the same as Edmentum, it's just showing them that immediate feedback so they know, ‘Oh wow, look it. I went up 10 points in math today.’ Or, however it may be.

In this case, Teacher S rewards students with extrinsic motivators in order to improve their scores on district assessments like Edmentum and NWEA.

After analyzing the data obtained from the Fall Delta Math screener, Teacher S engaged in the following instructional changes: reteaching and grouping. In reference to reteaching, Teacher S explained:

I think at this point it's going back, hitting those skills, trying to fix any of those errors that they may have. Because as we're moving on to other fourth grade standards, it's
going to be hard if they can't do the third grade standards.

Regarding the grouping of her students, Teacher S explains in the following exchange that during her WINN time, she spends two weeks on each of the readiness standards from the fourth grade screener. If students still aren’t successful on those standards, according to the quick check provided by Delta Math, she will work with those students in small groups.

And then for Delta Math we've made that calendar really follow that calendar. Once we finished that, knowing we have to move on as long as I have a majority of my class, with a three or four in their growth chart, we move on, but I still try to pull those two or lower to my front tables to see what's going on and try to get them to process and successfully complete those skills.

Careful analysis of this quote also reveals another instructional change not readily apparent in the review of the literature. Specifically, Teacher S developed and followed a schedule for interventions that was aligned to the Delta Math Readiness Standards. In this case, the data prompted her to develop a strategic plan for addressing the needs of her students. Additionally, this exchange reveals a more intentional use of formative assessment to make decisions about which students need additional instructional for a particular readiness standard.

Another instructional change, also not readily apparent in the review of the literature, is Teacher S’s decision to skip lessons in the Fourth Grade Go Math! text. Teacher S explained, “W and I are just looking at different Go Math! lessons and skipping them, just do the ones that we feel are most important.” Here she is using the Delta Math Readiness standards and results to make decisions regarding both the prioritization and elimination of content within core instruction. Additionally, her colleague Teacher W is supporting her in these decisions.
After analyzing the data obtained from the Winter Delta Math screeners, Teacher S engaged in the following instructional changes: reteaching, grouping and change in delivery. Teacher S relates the following insights regarding reteaching and grouping:

It also helps me see who already knows those skills, so I'm not repeating, going over the same exact skills, when there's only two kids who need that skill. So that helps me so I can plan my instruction better, pull out those students during the WINN time or any extra time we have.

Here Teacher S is being very targeted with her instruction, ensuring only those students who need additional support receive it.

With regard to a change in delivery, Teacher S shared this experience:

Yes. So comparing fractions before we met, were introduced to Delta Math, we, as a team, were on Pinterest, and found the butterfly method. And J. was like, ‘I hate the butterfly method.’ He's like, ‘Yes, but kids need to understand the different sizes and the different pieces.’ And then, it's like, ‘Okay, but it's still easier.’ And then this year as I'm diving into the Delta Math, I'm like, ‘Oh no, they have to understand the pieces to truly understand fractions.’ And the butterfly method just is so easy, but it's not teaching them the concept and the pieces of the fractions. So that's definitely changed my comparing fractions.

Careful analysis of Teacher S’s experience reveals that in order to support student understanding, she abandoned the butterfly method for comparing fractions. Instead, she employed a strategy that was provided by the Delta Math lessons with the support of the RESA math consultant.
Also during this interview, instructional changes occurred that weren’t identified in the initial review of the literature. These changes included reprioritization of content and more frequent formative assessment. In regard to reprioritizing content, Teacher S related this insight:

And then fourth grade standards show me what we have to get to, 'cause [sic] again, those are the standards that we want them to know by the end of fourth grade. So, again, both of those were used to help plan my instruction for the rest of the year.

Teacher S’s insights reveal that she will utilize the readiness standards from the Delta Math fifth grade screener to prioritize what content she will focus on for the remainder of the school year.

Figure 8 below lists the standards Teacher S intends to plan her instruction round.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.NBT.5</td>
<td>Multiply multi-digit numbers</td>
</tr>
<tr>
<td>4.NBT.6</td>
<td>Divide up to a four-digit number by a one digit number</td>
</tr>
<tr>
<td>4.NF.2</td>
<td>Compare two fractions</td>
</tr>
<tr>
<td>4.NF.3b</td>
<td>Convert between improper fractions and mixed numbers</td>
</tr>
<tr>
<td>4.NF.3c</td>
<td>Add and subtract mixed numbers</td>
</tr>
<tr>
<td>4.NF.4b</td>
<td>Multiply a whole number by a fraction</td>
</tr>
</tbody>
</table>

Figure 8. Delta Math fifth grade readiness standards

This interview also revealed that Teacher S chose to administer more frequent formative assessment to ascertain how her students were progressing in core content. She explains, “I'll print off other quick checks and give that to them, and it's kind of like an [exit 00:13:02] ticket, so I know where they're at, so during my core time.”

After analyzing the data obtained from the Spring Delta Math screeners, Teacher S engaged in the following instructional changes: grouping, more frequent assessment, becoming
standards driven, a better understanding of the standards, adjustments to pacing and reprioritization of content. The following best captures these changes:

So I think it's just, before it was, I'd pull maybe, maybe after chapter 10. So, you know if it takes a week, two weeks, three weeks, to get through chapter 10, then I'd pull. Where this was a lot more immediate, based on the results of the testing, when they did their quick checks in their book, if they didn't meet their goal, then I'd pull them, you know, revisit the skill.

Here Teacher S explains how instead of waiting until the chapter test to assess mastery, she utilized the quick checks to monitor student understanding. For students who are not progressing at an appropriate rate, she employs small group instruction.

Teacher S also explained how the data and lessons from Delta Math caused her to become more “standards driven.” When I inquired what she meant by “standards driven,” she explained:

So this year, it's a lot more standard-driven. We're looking at the standards, deciding how we're going to teach those standards, the amount of time we're going to teach them. And then using Go Math! as kind of, so we take those standards, decide what we're going to teach when, and then Go Math!, we pull the lessons and chapters we need from there, where before we just went right out the basic guide using Go Math!

Before this experience with Delta Math, Teacher S explained how she would simply go through the motions and teach the lessons in her Go Math! text. Now she is more intentional and more focused on the standard. Not only that, Teacher S noted how she had a better understanding of the standards as a result of this experience.
Finally, Teacher S shared how the data from Delta Math impacted her pacing and prioritization of content. She explains:

I was surprised at the progress that the students made, and I think what really helped was having those standards because before [inaudible 00:16:35] Go Math!, with two really thick books, and then trying to decide what standards to teach, well really what skills to teach, when to teach it, how long to teach it, where now, I think that I think they made huge gain in the areas that we really focused on, and didn't have ... it was more of the small picture versus the big picture of two math books and how were we going to get through all of it.

Again, both of these changes in instruction were not identified in the review of the literature. A summary of the instructional changes employed by Teacher S are summarized in Table 12 below.
Table 12

*Instructional Changes Employed by Teacher S During the 18-19 School Year*

<table>
<thead>
<tr>
<th></th>
<th>October 2018</th>
<th>November 2018</th>
<th>February 2019</th>
<th>June 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Interview</td>
<td>Fall Data Review</td>
<td>Follow-Up Interview</td>
<td>Winter Data Review</td>
<td>Follow-Up Interview</td>
</tr>
<tr>
<td>3. <em>Strategic Intervention Planning</em></td>
<td>3. Change in Delivery</td>
<td>4. Reprioritization of content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. <em>More Frequent Formative Assessment</em></td>
<td>4. Reprioritization of content</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Reprioritization of Content</td>
<td>5. More Frequent formative assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Here we see that over the course of the 18-19 school year, Teacher S employed a variety of instructional strategies in response to the data obtained from the Delta Math screeners. Teacher S employed seven different changes in instruction. Strategies not identified in the literature are italicized in the table above. Interestingly, she did not employ student reflection as one of her instructional changes.
Results of Cross Case Analysis as Connected to Research Questions

Research Question 1

Research question one is as follows: What types of mental models are applied during sensemaking within the Delta Math RTI Program data cycle? Over the course of the 18-19 school year, all four mental models were applied by the three participants, including nature of instruction, student understanding, test, and student characteristics. Model 1, nature of instruction, was employed by all three participants on 12 different occasions. Model 2, student understanding, was employed by all three participants on eight different occasions. Model 3, nature of the test, was employed by two of the participants on three different occasions. Finally, Model 4, student characteristics, was employed by all participants on seven different occasions. Overall, nature of instruction (Model 1) was applied with the greatest frequency, while nature of the test (Model 3) was applied the least. A potential new model, prior instruction, emerged on one occasion and was applied by only one participant. These results are summarized in the table below.

Table 13

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency of Application</th>
<th>Number of Participants who Applied the Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nature of Instruction</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>2. Student Understanding</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>3. Nature of Test</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4. Student Characteristics</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>5. Nature of Prior Instruction</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

These results reveal that overall teachers applied twice the amount of models associated with instructional change compared to models not associated with instructional change.
Specifically, nature of instruction and student understanding were applied on 20 different occasions while nature of the test and student characteristics were applied on 10 different occasions.

With regard to the first baseline interview, it is important to realize that these mental models were not applied to the Delta Math Readiness Screener. As such, it is necessary to review only the application of models that occurred in November, February, and March. During this time period, Model 1, nature of instruction, was employed by all three participants on nine different occasions. Model 2, student understanding, was employed by all three participants on seven different occasions. Model 3, nature of the test, was employed by one of the participants on one occasion. Finally, Model 4, student characteristics, was employed by all participants on four different occasions. Overall, nature of instruction (Model 1) was applied with the greatest frequency, while nature of the test (Model 3) was applied the least. A potential new model, prior instruction, emerged on one occasion and was applied by only one participant. These results are summarized in Table 14 below.

Table 14

*Application of Models Across Cases Excluding Initial Interviews*

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency of Application</th>
<th>Number of Participants who Applied the Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nature of Instruction</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>2. Student Understanding</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>3. Nature of Test</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4. Student Characteristics</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5. Nature of Prior Instruction</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
These results reveal that the participants applied nearly three times the amount of models associated with instructional changed compared to models not associated with instructional change to the Delta Math Readiness Screener. Specifically, nature of instruction and student understanding were applied on 16 different occasions while nature of the test and student characteristics were applied on five different occasions.

**Research Question 2**

Research question two is as follows: How do these mental models change over the course of the school year? In Table 15 below we see how the participants mental models changed throughout the course of the 18-19 school year.

Table 15

*Cross Case Analysis of Mental Models During the 18-19 School Year*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Instruction</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Student Understanding</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Nature of Test</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Student Characteristics</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Nature of Prior Instruction</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Here we see that nature of instruction was applied consistently by all three participants over the course of the year. There is also an interesting jump in the application of student understanding from October to November. Recall that the difference between the October interviews and the November interviews is the data source. In October, the participants were asked questions that pertained to the application of mental models to a variety of data sources. However, in November the participants were only asked questions to ascertain their application of mental models to the Delta Math Readiness Screener. Interestingly, the application of the models that are not associated with instructional change, nature of the test and student characteristics, decreased over the course of the school year. Finally, in the month of June only models associated with instructional change were applied by the participants. Overall, the results from this study confirm that mental models are not static and can change over time.

**Research Question 3**

Research question three is as follows: What type of instructional changes results from the application of these mental models? *Table 16* below summarizes the number of times the participants applied one of the instructional changes identified in the review of the literature.

Table 16

*Number of Times Each Instructional Strategy was Employed During the 18-19 School Year*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Reteach</th>
<th>Grouping</th>
<th>Change in Delivery</th>
<th>Student Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher W</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Teacher K</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Teacher S</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>11</strong></td>
<td><strong>5</strong></td>
<td><strong>4</strong></td>
</tr>
<tr>
<td><strong>Applications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Overall, grouping was the instructional change applied most frequently by the participants while student reflection was applied the least. Next Table 17 illustrates the various instructional strategies applied by the participants that were not readily apparent in the review of the literature.

Table 17

*Number of Times Each Instructional Strategy Not Apparent in the Literature was Employed During the 18-19 School Year*

<table>
<thead>
<tr>
<th>Participant</th>
<th>Strategic Intervention Planning</th>
<th>Reprioritization of Core Content</th>
<th>Realignment of Tier 1 and Tier 2 Content</th>
<th>More Frequent Formative Assessment</th>
<th>Reward System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher W</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Teacher K</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Teacher S</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Careful analysis of these results reveals a total of five new potential changes in instruction that were not apparent in the review of the literature. Overall, reprioritization of core content was applied most frequently amongst all three participants. It is important to note that the Reward System instructional strategy was applied to other data sources and not to the Delta Math Readiness Screener Results. Additionally, these strategies aren’t necessarily new practices. What is potentially unique here is that the data source, Delta Math, prompted these instructional responses. What follows are potential definitions for each of the newly identified instructional responses to data with exemplar participant quotes from the study.
**Strategic Intervention Planning** - The intentional use of data to determine what specific skills and concepts will be addressed during the intervention block. The planning could also include the order of how these skills are taught, along with the amount of time that will be devoted to each identified skill. The following explanation from Teacher W best captures this instructional response:

Oh, it's definitely helpful. It completely changed my...well, it guided my WINN timed instruction, What I Need is what we call it, our WINN time. We do it for math, and that's new this year, and I didn't really know where to start. So, that gave me basically my exact curriculum that I'm following with the lessons because we are using the Delta lessons along with the screener and the quick checks, and it's my entire WINN curriculum for my class.

**Reprioritization of Core Content** - The practice of selecting a particular set of skills and content over another set. This practice may result in the elimination of content, and additionally it may have an impact on how content is scoped and sequenced. The following explanation from teacher W best captures this instructional response:

I don't want to say that it's changing my instruction, but I feel like it's probably driving where I'm going in my instruction because I might only really hit the readiness standard in my curriculum because of the time frame. Then, that leaves some stuff left undone, unfortunately, but it's basically 10, 11, 12 weeks left, whatever it is. There's only so much time, and I feel like the readiness standards will drive where I'm going. Then, hopefully, I'll have enough time to go back and hit more, but I feel like that's what I'm going to really focus on. Then, also use that for intervention when I'm done with that chapter. Does that make sense?
Aligning Tier 1 and Tier 2 Content - The practice of aligning similar skills and concepts between grade level content (Tier 1) and prior grade level content (Tier 2). The following explanation from teacher K best captures this instructional response:

So I was teaching different skills than what we're necessarily going over in our math WINN with Delta. I decided to match them up. So what they're doing in the curriculum right now, fourth grade is doing division; they're just doing easier division. Fifth grade's doing division, and in math WINN, we're doing division. So I'm just hitting it more all around. Whereas before, I was teaching like, for example, fourth grade would be doing area and perimeter, and for Delta WINN, we were doing multiplying multi-digit numbers or fractions on a number line or something. It may or may not have gone hand-in-hand, now it's altogether.

Utilize Delta Math Lessons to support Core Instruction - This is the practice of utilizing Delta Math Lessons as a supplement or even instead of the identified core resource. In this case the core resource, was the Go Math! textbook. Teacher K observed, “I tied in as much as I could to the core. I didn't do as much from Go Math. I kind of relied heavily on the Delta because I really feel like Delta has the skills that they need.”

Rewards System - While this practice was not applied to the results obtained from the Delta Math Readiness screener, it is the practice of rewarding students with extrinsic motivators like food or movies in the hope of engaging them in learning and mastering critical content. The following exchange with Teacher S best illustrates this practice.

Okay. In our class, fourth grade, we started with almost like an award system because a lot of the students do not take tests serious [sic], they don't really understand the value of the test, ‘whoop-de-do.’ But we did more of like a rewards system where, in
Edmentum if you went up in one of the three areas, you receive a movie. You went up for two out of the three you received a movie and popcorn. Then all three [sic] was movie, popcorn, pop. So they see that not only [inaudible 00:11:25] important that when you do try hard to get things in return. With the NWEA, which I feel would be the same as Edmentum, it's just showing them that immediate feedback so they know, ‘Oh, wow, look it., I went up 10 points in math today.’ Or, however it may be.

*More frequent formative assessment.* The practice of providing more formative assessment opportunities for students before conducting a summative assessment like a unit test. This practice allows the teacher to continually monitor student progress and adjust core instruction as necessary. The following explanation from Teacher S best summarizes this practice. “I'll print off other quick checks and give that to them, and it's kind of like an [exit 00:13:02] ticket, so I know where they're at, so during my core time.”

In summary, this cross-case analysis reveals that while all four mental models were applied to the data obtained from the Delta Math Readiness screeners, models associated with instructional change were applied more frequently. Over the course of the 2018-2019 school year, there was a change in the application of mental models by all the participants. Specifically, toward the end of the study, the application of the models not associated with instructional change seemed to diminish. Finally, all instructional changes readily apparent in the review of the literature were applied, along with five additional instructional strategies that were not readily apparent in the literature.
CHAPTER VI

SUMMARY, DISCUSSION AND RECOMMENDATIONS

This chapter offers a revised conceptual framework that illustrates how my research confirms previous findings and elevates the dialogue around data-driven decision making. Specifically, this chapter summarizes new findings including a potential fifth model and additional changes in instructional practice. A discussion on how these findings can support educational leaders in ensuring that teachers can respond in meaningful ways to achievement data is provided. Finally, I will articulate recommendations for future study.

Revised Conceptual Framework

The previous findings allow me to expand upon and revise the conceptual framework that was developed at the start of this study. As seen in Figure 9, each of the new findings has been placed within the conceptual framework of data-driven decision making and are highlighted in yellow. The remaining elements of the conceptual framework were confirmed in my study during data collection.
Figure 9. Revised Conceptual Framework (Bingham, 2019)
Within Sensemaking about Student Outcomes note that an additional mental model, prior instruction, was added. Based on the data collected from this study, it is possible that this model presents an external locus of control that is unstable and uncontrollable. If a teacher attributes the outcomes of data to prior instruction, they may believe that their students lack grade-level skills because their previous educators did not provide rigorous instruction. Application of this model may result in a teacher feeling a lack of control around data outcomes and may not yield a change in instruction. Further research is necessary in order to better ascertain how this mental model is applied as teachers make sense of data from various sources.

With regard to Possible Future Responses, notice the addition of the Venn Diagram. The previous conceptual framework illustrated that teachers only engaged in instructional change if they applied the positive mental models of instruction and student understanding. However, data collected from this study indicate that a teacher could apply both positive negative mental models and still engage in some type of instructional change. In all three cases, if a teacher applied a negative mental model, it was coupled with a positive mental model. Also notice that the new mental model, prior instruction, has been added to the types of mental models that do not result in a change in instruction. Further research is necessary to confirm these additions to the framework.

Finally, within the types of Instructional Change, five new changes have been added. These include reward systems, reprioritization of core content, strategic intervention planning, more frequent formative assessment, and realignment of tier one and tier two content. Again further research is necessary to obtain a richer description of these instructional changes. Additionally, it may be beneficial to investigate whether or not these specific instructional changes arise when teachers make sense of data sources other than Delta Math.
Implications for Practice

Upon the completion of my research, I believe there are several implications for practice that can ultimately elevate how teachers engage in data-driven decision making. The first implication for practice is for school leaders to consider the data sources that will allow for instructional change amongst educators. As previously stated, teachers are bombarded by student achievement data from a variety of sources. However, many data sources do not necessarily support the application of positive mental models, which, in turn, do not prompt a change in instructional practice. Specifically, none of the participants in this study found the data obtained from M-STEP to be an actionable data source. Additionally, teachers in this study struggled to utilize data obtained from NWEA and other district level assessments. However, the data obtained from the Delta Math Readiness Screener not only supported the application of positive mental models by the participants, but it also prompted the utilization of instructional changes. These changes in instruction ultimately supported gains in student achievement. With this in mind, school leaders need to carefully consider the achievement data that teachers review. The process of data analysis can be time consuming, and if the data source does not promote the application of positive mental models, then the school leader may want to consider another data source or limit the amount of time allocated for analysis.

The second implication for practice is for school leaders to consider the types of support needed to allow teachers to employ instructional changes. The participants in this study were provided a variety of supports, including time for collaboration, a math consultant, and lessons aligned to the readiness standards. Interestingly, this study revealed changes in practice that were not readily apparent in the review of the literature. And while this study cannot prove that these additional supports allowed for these new changes in instruction to emerge, school
administrators may want to consider how they will support teachers in changing their practices. While the intentional review of data can provide teachers insight into the necessity for change, it may not provide the guidance necessary for how to change.

As I reflect upon all of the changes that were employed by the participants during this study, one of the most striking came as a result of a gentle nudge from the math consultant. During the course of this study, Teacher S shared how she utilized the butterfly method to help students compare fractions. And while this is an efficient strategy, it does not support conceptual understanding. In order to change this practice, Teacher S needed additional support. In this case, she found support in two ways. First, the Delta Math lessons articulated a different strategy utilizing common denominators that better encouraged student understanding. Second, the math consultant encouraged her to try the new strategy by arguing that the butterfly method was a short-term fix and that long term it was not the best way to improve student achievement.

In summary, it is my hope that this study prompts school administrators to be more intentional in their selection of data sources. But more importantly that they provide support for teachers to make the changes necessary to improve student outcomes.

**Implications for Future Research**

The hope of this multiple case study was to fill a hole within the literature regarding the mental models that teachers applied to the data obtained from the Delta Math Readiness Screeners. Additionally, this study articulated how the application of mental models changed over time and provided a rich description of the various types of instructional changes that were employed. This section discusses the recommendations for future research in an effort to elevate the conversation around data-driven decision making.
The first recommendation would be to conduct research that digs deeper into the potential fifth mental model — prior instruction. Specifically, this study could be duplicated to see if it emerges in other cases. Additionally, studies could be conducted to determine if this mental model is applied to other data sources, such as state assessments, district assessments, or classroom assessments. Finally, qualitative studies could be designed to confirm whether or not the locus of control for this potential new model is external, unstable, and uncontrollable.

The second recommendation is that additional research could be done around the five new instructional changes that were identified in this study. These instructional changes include (a) reward systems, (b) reprioritization of core content, (c) strategic intervention planning, (d) more frequent formative assessment, and (e) realignment of tier one and tier two content. Are these instructional changes only realized after analyzing the data obtained from the Delta Math Readiness screener? Or do other data sources, like state, district or classroom assessments, support these instructional changes? Additionally, future studies could provide a more rich description of these instructional changes.

The third recommendation is to study teacher responses if teachers were only provided screener data and no other supports. A review of the participants selected for this study reveals that in many ways they are exemplar. Teachers were required to provide intervention time by the administrator. This team was collaborative and willing to work together. They had access to instructional resources and systems that allowed them to respond to the data they were provided from the screener. Furthermore, these three educators were given access to a math consultant that supported them in changing their instruction. District administration also provided time for the teachers to review and respond to the data. Overall, these teachers in this study were provided with more than just the data obtained from the screeners. Further research could be conducted to
determine what instructional changes emerge if the teachers were only provided screener data and no other supports. Would the instructional changes identified both in the literature and in this study emerge?

The final recommendation is to study what would happen if a teacher only applied a negative model. This study revealed that the application of both positive and negative models resulted in various instructional changes. Additional studies could be conducted to identify specific participants who only apply negative mental models to various data sources. It may be interesting to investigate if these participants are able to apply positive mental models to Delta Math Screener data. In this study all three participants were capable of applying positive mental models to data, as established by the initial baseline interviews. But, what if a participant didn’t naturally employ those models? Would we still see change over time in the application of the models? What instructional strategies, if any, would these specific participants employ?

**Concluding Thoughts**

This study did confirm much of the research conducted in previous studies but also added some new findings that could be useful in elevating the practice of data-driven decision making. The purpose of this multiple case study was to investigate the mental models that teachers apply to data obtained from the Delta Math Readiness screener. Over the course of the 18-19 school year, all four models, including instruction, student understanding, nature of the test, and student characteristics, were applied. Instruction and student understanding, models associated with instructional change, were applied more frequently throughout the year, by all three participants. While the application of mental models not associated with instructional change, nature of the test and student characteristics decreased throughout the year. Interestingly, this study demonstrated that a teacher could apply a negative mental model in conjunction with a positive
mental model and a change in instruction could still occur. Of significant interest, this study also revealed a potential fifth mental model, prior instruction. This model seems to occur when teachers attribute student outcomes to the quality of instruction received in prior grade levels. Preliminary findings indicate that this model is not associated with a change in instruction.

My research also provided the field with a detailed description of the types of instructional changes teachers employed as a result of the applied mental models. This study confirmed the four types of instructional changes articulated in the literature. These changes include (a) reteach, (b) grouping students, (c) student reflection, and (d) change in delivery. Additionally, this study revealed new changes in instruction including (a) reward system, (b) reprioritization of core content, (c) strategic intervention planning, (d) more frequent formative assessment, and (e) realignment of Tier 1 and Tier 2 content.

Overall, this study has furthered the discussion around data-driven decision making by calling attention to a screener that promotes the application of positive mental models and supports instructional change. Those in K-12 leadership roles can benefit from this research, as they make decisions around the data sources that empower practitioners to engage in new techniques that bolster student achievement. Educational leaders can utilize the results from the year-long study to develop supports, such as time for collaboration, educational consultants, and instructional resources to support teachers in intentionally responding to data.
Appendix A
Telephone Recruitment Script

● Greeting and introduction, including my (Ann’s) name and title.
● Reason for calling - You have been identified as an administrator that utilizes the Delta Math Screener.
● Information about the research project.
● Methods of Data Collection - Over the course of the year, I will observe three Delta Math review meetings and interview each teacher in the selected grade level four times. The first interview will be conducted at the beginning of the study before the initial review of the data. Subsequent reviews will then be conducted after each of the three data team meetings. Interviews will last up to 60 min. each.
● If the prospective participant indicates interest, I will let him/her know that I will follow-up with an email describing what we have talked about and the consent form that will need to be signed by him/her and all the participating teachers prior to the first interview.
Appendix B
Email Recruitment Script

Dear Potential Participant,

My name is Ann Bingham, and I am the Director of Curriculum, Instruction and Assessment at Niles Community Schools. I am also completing my Ph.D. studies in Educational Leadership at Western Michigan University and would like you to participate in a research project that I think will benefit how teachers utilize data to inform and change instruction. The purpose of this study is to describe and interpret how teachers engage in sensemaking of data obtained from Delta Math. Additionally, this study will investigate the types of instructional changes that are employed by teachers as a result of this sensemaking process. This research project is part of the requirements for the doctoral degree program in Educational Leadership at Western Michigan University, in which I am a student. You were recommended for this study by your district or building-level administrator.

Participants in this study will be asked to participate in two ways: observation of three Delta math data review meetings and four face-to-face or phone interviews with the researcher. Upon completion of the observation and interview, the participant will be asked to review a summary for accuracy. In total, participation in this study will take approximately 650 minutes of an individual participant’s time during the 18-19 school year. All data collected for this study will be kept confidential, and only the researcher will know the names and schools of actual participants. Results of this study will be shared with your organization; however, only mental models and instructional changes will be reported. All participants will remain anonymous.

Finally, for the district participating in this study, the results may help inform the extent to which Delta Math is supporting changes in instruction within classrooms. Understanding whether or not Delta Math supports mental models that allow for changes in instruction is important for administrators and teachers, as they prioritize the myriad of data sources they utilize.

If you are interested in participating in this research study, please review the attached participant consent form. Should you have questions or need more information about this study, please contact me by email at (ajames@wmich.edu) or by phone at (616-889-2733).

After reviewing the consent form, if you are interested in participating in this research study, please sign the consent form and return it to me via email. Thank you for your consideration of this request to be a part of an important study.

Sincerely,
Ann Bingham
Appendix C
Consent Form
Western Michigan University

Principal Investigator: Dr. Jianping Shen
Student Investigators: Ann Bingham

Title of Study: The role of mental models in sensemaking during the data-driven decision making process and their impact on instructional practice.

You have been invited to participate in a research project titled “The role of mental models in sensemaking during the data-driven decision making process and their impact on instructional practice.” This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification. This study is being conducted as part of a dissertation at Western Michigan University.

What are we trying to find out in this study?
We are attempting to describe and interpret how teachers in grades 1-5 engage in sensemaking of data obtained from Delta Math. Additionally, this study will investigate the types of instructional changes that are employed by teachers as a result of the sensemaking process.

Who can participate in this study?
We are seeking 1st through 5th grade teachers who utilize the Delta Math Readiness Screener and conduct grade level data review meetings.

Where will this study take place?
This study will take place at your school and/or over the phone.

What is the time commitment for participating in this study?
We anticipate the total commitment to this study to be approximately 650 minutes. Each of the three observations will last up to 90 mins. while each of the four interviews should last up to 60 minutes. After each interview and observation, the participants will be asked to spend up to 20 minutes reviewing a summary and provide feedback on its accuracy.
What will you be asked to do if you choose to participate in this study?
Participants in this study will be asked to participate in three ways: observation of a team data meeting, face-to-face or phone interviews with the researcher, and review a summary of the interviews for accuracy.

What are the risks of participating in this study and how will these risks be minimized?
There are no anticipated risks to this study. However, pseudonyms will be assigned for use in place of the school name and participant names during publication or presentation of findings.

What are the benefits of participating in this study?
The benefit of participating in this study is that it may enrich scholarly dialogue by providing additional insight into the application of mental models to the Delta Math readiness screener. Additionally, participation in this study will add a rich description to the resulting changes to instruction, if any. This study may provide school administrators and teachers with insight into how to prioritize the myriad of district- and building-level assessments.

Who will have access to the information collected during this study?
Only the researchers will have access to the interview recording. The transcripts will be stored on a secure server and accessed only by the researchers.

What if you want to stop participating in this study?
You may choose to stop participating in this study at any time for any reason without consequence or question.

Should you have any questions prior to or during the study, you may contact the primary investigator, Dr. Jianping Shen at 269-387-3540 or jianping.shen@wmich.edu. You may also contact the Research Compliance Office at 269-387-8293, the Vice President for Research at 269-387-8298, or the student researcher, Ann Bingham at 616-889-2733 or ajames@wmich.edu, if questions arise during the course of the study.
This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

Please Print Your Name _____________________________________

Date _____________________________

____________________
Participant’s signature
Appendix D
Observation Protocol

Before conducting, remind participants that they are participating in a study entitled “The role of mental models in sensemaking during the data-driven decision making process and their impact on instructional practice.” Their role in this study is completely voluntary, and they may stop participation at any time. Pseudonyms will be assigned during transcription. Confidentiality will also be maintained when discussing results with the site administrator.

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Appendix E
Interview Protocols

Interview 1 Protocol

● Introduction and consent to record
● Turn on recorder
● Explanation of the study
● Length of interview, approximately 60 min.
● Confidentiality
● Reminder that after transcription the participant will be given the opportunity to add to and review comments made for accuracy
● Questions or concerns before we begin?

Questions adapted from Farrell & Marsh, 2016

1. Would you please tell me about yourself and your current position? (Probes: How many years have you taught? What grades have you taught? How long have you been in the district?)
2. In developing your lessons and plans for instruction in mathematics, what generally guides the choices you make about what to teach and how to teach it?
3. What do you think causes student outcomes on a state assessment, like M-Step? (RQ.1)
4. To what extent do you feel you have control over student outcomes on a state assessment, like M-Step? (RQ.1)
5. Please describe how you respond to student data from a state assessment, like M-Step. (RQ.3)
6. What do you think causes student outcomes on a district level assessment, such as NWEA or Dibels? (RQ.1)
7. To what extent do you feel you have control over outcomes on a district level assessment, such as NWEA or Dibels? (RQ.1)
8. Please describe how you respond to student data from a district level assessment, such as NWEA or Dibels. (RQ.3)
9. What do you think causes student outcomes on a classroom assessment, such as a quiz or a unit test? (RQ.1)
10. To what extent do you feel you have control over student outcomes from a classroom assessment, such as a quiz or a unit test? (RQ.1)
11. Please describe how you respond to student data from a classroom assessment, such as a quiz or unit test. (RQ.3)
Interview 2 Protocol

- Introduction and consent to record
- Turn on recorder
- Explanation of the study
- Length of interview, approximately 60 min.
- Confidentiality
- Reminder that after transcription the participant will be given the opportunity to add to and review comments made for accuracy
- Questions or concerns before we begin?

Questions adapted from Farrell & Marsh, 2016

1. Do you think that the data you obtained from the Fall Delta Math Readiness Screener is a good measure of your students’ skills? Why or Why not? (RQ.1)
2. Is the data from the Delta Math Readiness Screener helpful to you? How? (RQ.1)
3. Have you made changes since you reviewed these results? Why? If you changed your instruction based on the Delta Math results, can you provide examples of those instructional changes? (RQ.3)
4. If you did not change instruction, please explain why. (Probe here to ascertain if they engaged in Model 3 (Nature of the Test) or Model 4 (Student Characteristics) (RQ.3)
Interview 3 Protocol

- Introduction and consent to record
- Turn on recorder
- Explanation of the study
- Length of interview, approximately 60 min.
- Confidentiality
- Reminder that after transcription the participant will be given the opportunity to add to and review comments made for accuracy
- Questions or concerns before we begin?

Questions adapted from Farrell & Marsh, 2016

1. Do you think that the data you obtained from the Winter Delta Math Readiness Screener is a good measure of your students’ skills? Why or Why not? (RQ.1)
2. Is the data from the Delta Math Readiness Screener helpful to you? How? (RQ.1)
3. Have you made changes since you reviewed these results? Why? If you changed your instruction based on the Delta Math results, can you provide examples of those instructional changes? (RQ.3)
4. If you did not change instruction, please explain why. (Probe here to ascertain if they engaged in Model 3 (Nature of the Test) or Model 4 (Student Characteristics) (RQ.3)
Interview 4 Protocol

- Introduction and consent to record
- Turn on recorder
- Explanation of the study
- Length of interview, approximately 60 min.
- Confidentiality
- Reminder that after transcription the participant will be given the opportunity to add to and review comments made for accuracy
- Questions or concerns before we begin?

Questions adapted from Farrell & Marsh, 2016

1. Do you think that the data you obtained from the Spring Delta Math Readiness Screener is a good measure of your students’ skills? Why or Why not? (RQ.1)
2. Is the data from the Delta Math Readiness Screener helpful to you? How? (RQ.1)
3. Have you made changes since you reviewed these results? Why? If you changed your instruction based on the Delta Math results, can you provide examples of those instructional changes? (RQ.3)
4. If you did not change instruction, please explain why. (Probe here to ascertain if they engaged in Model 3 (Nature of the Test) or Model 4 (Student Characteristics)) (RQ.3)
Appendix F

Code Book

Model 1
1. Classroom instruction influences student learning, which is reflected in data.
2. My instruction causes student outcomes.
3. My instruction is not always the same.
4. I am in control of my instruction.

Model 2
1. Student understanding affects outcomes on assessment.
2. Student understanding can change.

Model 3
1. If, on a teacher-created assessment, the majority of the students score proficient, the teachers created a test that was too easy for the students.
2. If, on a teacher-created assessment, the majority of students did not score proficient, the teachers created a test that was too difficult for students.
3. If, on an assessment that is not teacher created, the majority of students score proficient, the assessment is too easy for students.
4. If, on an assessment that is not teacher created, the majority of students do not score proficient, the assessment is too difficult for students.
5. Assessments that I develop reflect what my students know and don’t know.
6. Assessments that I don’t develop don’t reflect what my students know and don’t know.
Model 4

1. Certain groups of students have inherent abilities and attributes, which affect their learning and outcomes.

2. Higher order thinking is not appropriate in the instruction of low-achieving students.

3. I am not surprised when certain students score below proficient on an assessment because they are unmotivated and lack work ethic.

4. Certain students will never be proficient on an assessment.
Appendix G
HSIRB Approval Letter

Date: October 1, 2018

To: Jianping Shen, Principal Investigator
    Ann Bingham, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 18-09-06

This letter will serve as confirmation that your research project titled “The Role of Mental Models in Sensemaking During the Data-Driven Decision Making Process and Their Impact on Instructional Practice” has been approved under the expedited category of review by the Western Michigan University Institutional Review Board (IRB). The conditions and duration of this approval are specified in the policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes to this project (e.g., you must request a post-approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: September 30, 2019
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