PROMOTING TEACHING AS DESIGN
IN ELEMENTARY MATHEMATICS:
EXPLORING THE POTENTIAL
OF CURRICULUM SUPPORT MATERIALS

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Abstract

This design research study explored the potential of Curriculum Support Materials for promoting teaching as design. Conducted over a four-month period, the study traced the design, development, and pilot testing of a web site intended to serve as a professional development resource for teachers. The purpose of this exploratory study was to evaluate the web site’s potential for promoting elementary mathematics teachers’ understanding of teaching as a design activity and for supporting teachers in engaging in teaching as design. A team of four second grade teachers tested the web site during a two-week pilot unit on introducing the concepts of multiplication and division. Qualitative data were collected from these teachers through a planning and teaching log, a post-unit questionnaire, and a post-unit focus group interview. The findings indicated that the web site had the potential to promote teachers’ understanding of teaching as design, but that the web site’s potential as a stand-alone resource for supporting teachers in engaging in teaching as design was limited. Two specific features of the web site, the Unit Checklist and the videos addressing the related mathematics content, were identified as potentially valuable resources that could be incorporated into an ongoing professional development experience. Suggestions for revisions to the web site are discussed along with recommendations for further study.
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Dedication

This work is dedicated to my wife, Susan Schulz. You have helped me grow up, and I am a better teacher, husband, father, and son because of you. I am so lucky to have you to share my life with – we really do make a great team. Thank you for everything. I love you, Pie.
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CSM web site excerpt: Home – Mission

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CSM web site excerpt: Teaching as Design – Defining and introducing teaching as design (Merriam Webster Online Dictionary, 2011; Wiggins & McTighe, 2005, p.13)

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Time line of the study
Chapter 1: Introduction

In August 2007, I became the Mathematics Supervisor for a public school division in Virginia that had been using a Standards-based mathematics curriculum program\(^1\) in Grades K-5 since 2000. I faced a persistent challenge over the next two years in trying to reconcile the goals of this spiral curriculum program with the demands of the Virginia Mathematics Standards of Learning (SOL), which are tested annually in Grades 3-5. Many of our elementary mathematics teachers expressed frustration with the disconnect between the two, frequently asking me, “Do we teach the program or do we teach the SOL?”

Having used this curriculum program for the previous six years in my own 5\(^{th}\) Grade classroom, I was perplexed by the “either/or” nature of this question. The way I saw it, the state standards were obviously non-negotiable (if for no other reason than the fact that they formed the basis of the state tests used to determine Adequate Yearly Progress\(^2\)), and the curriculum program was intended to provide resources to address those standards. In the event of a gap between the curriculum program goals and the SOL, the SOL took precedence, requiring me to provide additional instruction to supplement the program, either by revising existing program resources or developing new lessons altogether. In other words, the state standards helped me establish my instructional goals and the curriculum program was a tool (but not the only tool) I used to help my students reach those goals. I was surprised to learn that other teachers in my school division were not approaching their mathematics instruction in this way.

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\(^1\) One of the several curriculum programs developed in the 1990’s with funding from the National Science Foundation and intended to support the *Curriculum and Evaluation Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 1989).

\(^2\) “Title I of the federal *Elementary and Secondary Education Act*, as reauthorized by the *No Child Left Behind Act (NCLB)*, requires states to establish standards, assessments, and accountability systems to ensure that every child achieves proficiency in reading and mathematics by the year 2014. …each state must also set standards for making “adequate yearly progress” (AYP) toward the goal of 100 percent proficiency. To make AYP, schools must meet proficiency targets not only for the school as a whole but also for student subgroups, including major racial and ethnic groups, economically disadvantaged students, students with disabilities, and students with limited English proficiency” (Gill, Lockwood III, Martorell, Setodji, & Booker, 2009).
Through conversations with elementary teachers and principals during my first two years as a curriculum supervisor, I discovered that, since the adoption of the curriculum program, many teachers had felt pressured by their principals to adhere strictly to the program, consistently cajoled to “trust the spiral” eventually to address all of the K-5 state standards. Several principals, in turn, reported having felt pressure from the district’s central office to ensure that teachers were implementing the program with fidelity. This conflict between the curriculum program and the state standards steadily grew sharper as Virginia’s Annual Measurable Objectives\(^3\) for mathematics continued to increase each year and our division struggled to meet the benchmarks for our subgroup populations, especially for students classified as Economically Disadvantaged\(^4\).

One of my responsibilities as Mathematics Supervisor was to try to resolve this issue, which I found challenging since I had not experienced the conflict to the same extent when I was a classroom teacher. In order to find a solution, I needed the answers to two important questions: 1) How should teachers be using curriculum materials? 2) How could a curriculum supervisor support teachers in using curriculum materials differently?

An Opportunity Presents Itself

In 2009, the Virginia Mathematics SOL (Commonwealth of Virginia Board of Education, 2009) were revised, resulting in significant changes to the instructional content for grades K-5. These changes included moving several challenging concepts from middle school to the upper-elementary level and placing an increased emphasis on application and conceptual understanding.

\(^3\) “Among the requirements for schools and divisions to make Adequate Yearly Progress (AYP) under the No Child Left Behind Act of 2001 (NCLB), they must meet certain benchmarks or Annual Measurable Objectives (AMOs) in reading and mathematics” (Virginia Superintendent’s Memo #106-11, 2011).

\(^4\) “A student is economically disadvantaged if he/she: (1) is eligible for free or reduced-price lunch; (2) receives TANF (Temporary Aid for Needy Families); or (3) is eligible for Medicaid” (Virginia Department of Education, 2011, p. 9).
over procedural knowledge (see Virginia Department of Education, 2010). The Virginia Department of Education (VDOE) scheduled the full implementation of the revised Standards for the 2011-12 academic year\(^5\) and, consequently, my school division scheduled its K-5 mathematics textbook adoption for 2010-11. As Mathematics Supervisor, I would be responsible for overseeing the textbook adoption process and creating materials aligning the new textbooks with the state standards and guiding our teachers’ instructional pacing. Such support materials would be intended to help teachers use the new textbooks to address the 2009 Standards successfully. These circumstances presented an excellent opportunity for me to learn about teachers’ use of curriculum materials and to explore new ways to support my teachers’ use of curriculum materials as we transitioned to the new standards.

**Definition of Terms**

Before proceeding further, it is necessary to distinguish between the terms *curriculum*, *curriculum materials*, and *curriculum program*. I define *curriculum* as a continuously evolving plan for action by students and teachers to produce desired student learning (this definition is fully developed in Chapter 2). Following the conventions established by Remillard, Herbel-Eisenmann, and Lloyd (2009), *curriculum materials* will be used to refer to “the specific print materials with which teachers and students have physical contact” (p. xvii), while *curriculum program* will be used to refer to “the larger program to which the physical materials belong (e.g., *Everyday Mathematics* is a *curriculum program*…)” (p. xvii).

In addition, I will introduce the term Curriculum Support Materials (CSM; see Chapter 5) to describe locally-developed instructional and professional development resources intended to serve as an intermediary between teachers and curriculum materials and develop teachers’

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\(^5\) [Virginia Superintendent’s Memo #138-09](#138-09)
understanding of the purposes and possible uses of the curriculum materials (see M. W. Brown, 2009).

**Needs Assessment**

In the spring of 2010, I conducted an evaluation of my district’s existing curriculum documents for K-5 mathematics (Schulz, 2010), which consisted of a Curriculum Guide for Grades K-5 and a Benchmark Test Blueprint for Grades 3-5 (samples of these documents are included in Appendix A). Data was collected using an anonymous electronic teacher survey and a focus group interview. This formative evaluation was intended to inform the design of future K-5 mathematics CSM.

The findings of this evaluation (see Appendix B) indicated that, despite the fact that many teachers found the documents to be overwhelming and difficult to use, the majority of teachers were still referring to the documents when planning their instruction. The evaluation yielded several recommendations from teachers for the improvement of the documents, including the creation of an online clearinghouse of instructional resources organized by the Virginia SOL for Mathematics. In addition, teachers requested resources related to the teaching and learning of mathematics to help them better understand children’s mathematical development and deliver instruction that promotes students’ understanding of important concepts. The following summary of the purpose of such curriculum support materials was met with unanimous agreement by the focus group interview participants when presented orally at the end of the interview:

“[The CSM] should guide you so you know where you’re supposed to be and when; help you understand where the kids are coming from and where they’re going; and help the
teacher with the math. They should be easy to use technologically, but they’re really about resources.”

This evaluation served as the needs assessment for my dissertation, and the findings were the driving force behind the current study: Many elementary mathematics teachers in my district were asking for online resources to support their use of the textbook to address state standards.

**Purpose of the Study**

This study focused on the design, development, and pilot testing of a set of online Curriculum Support Materials (CSM) aimed at promoting mathematics teaching as design. The purpose of this study was to explore the potential of CSM for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design.

**Research Questions**

This study was guided by two research questions:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

My desire to explore the “how” and the “why” of the impact of the characteristics of the CSM was implicit in these questions.

Because this was an exploratory study, it focused on the design, development, and pilot testing of the CSM, and did not include a full-scale implementation. This study did not seek to obtain conclusive evidence of the CSM’s effectiveness, but instead attempted to learn about their potential (McKenney, 2001) for promoting teaching as design. The results of this study will
inform the revision of the piloted CSM, guide the design of future CSM, and lay the groundwork for the study of future district-wide implementation.

**Why Teaching as Design?**

To answer the question *How should teachers be using curriculum materials?*, I reviewed the existing literature and found that the study of teachers’ use of mathematics curriculum materials is a relatively new field of research that has been developing rapidly over the last fifteen years (Remillard et al., 2009). This research was initially spurred by questions regarding the effectiveness of mathematics curriculum programs in the 1990’s (Remillard et al., 2009), especially the *Standards*-based programs that were developed through funding from the National Science Foundation (see e.g., Senk & Thompson, 2003). This research has been founded on changing conceptions of teacher practice. A research review by Clark and Peterson (1986) noted the importance of teachers’ thought processes as “moderating contextual factors” that impact the planning and delivery of instruction, and Thompson (1984) found that “teachers’ views, beliefs, and preferences about mathematics… influence their instructional practice” (p. 125; also see Wilkins, 2008). The work of Shulman (1986), Peterson et al. (1989), and Ben-Peretz (1990) further established this view of teachers as decision makers who evaluate and interpret curriculum materials to plan and deliver instruction. These ideas helped to characterize teachers as users, rather than merely implementers, of curriculum (Lloyd, Remillard, & Herbel-Eisenmann, 2009).

This characterization of teachers as decision makers can be extended to frame teaching as a design activity. M. W. Brown and Edelson (2003) argued that teaching is a design activity because “teachers must perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance tradeoffs and devise strategies – all in the pursuit of their instructional
goals” (p. 1). Wiggins and McTighe (2005) also supported the idea of teaching as design, explicitly stating that: “Teachers are designers. An essential act of our profession is the crafting of curriculum and learning experiences to meet specified purposes” (p. 13). This positioning of teachers as designers and curriculum materials as tools aligns with other research (McClain, Zhao, Visnovska, & Bowen, 2009; Stein & Kim, 2009) and matches my experiences as a classroom teacher and curriculum supervisor: Teachers are decision makers who use curriculum materials as tools to design and deliver instruction, and teaching is a design activity.

**Why Design Research?**

Design research (see Chapter 4) is a flexible research method that can be applied to a wide range of research questions. This study was well-suited for a design research approach for four reasons: the exploratory nature of the study; the nature of the research questions; the nature of the product that the study aimed to develop and evaluate; and the alignment of the study with the four key principles of design research. Each of these reasons will be discussed in turn.

**The Exploratory Nature of the Study**

Edelson (2006) noted the exploratory nature of design research, stating that two key questions of design research are 1) “What alternatives are there to current educational practices?” and 2) “How can these alternatives be established and sustained?” (p. 103). Kelly (2006) contrasted design research with randomized field trials, which he described as “confirmatory and conservative” (p. 113), asserting that design research is “exploratory and ambitious” (p. 113). Kelly extended this idea, making three key points about the nature of design research:

- “Design research is experimental, but not an experiment. It is hypothesis generating and cultivating, rather than testing; it is motivated by emerging conjectures” (p. 114).
“Design research may be seen as a *stage-appropriate response* in a multi-stage program of research that moves from speculation, to observation, to identification of variables and processes via prototyping, to models and more definitive testing of those models, to implementation studies, scaling studies, and ongoing diffusion of innovations” (p. 114).

“Design researchers choose to work in the ‘context of discovery’ rather than the ‘context of verification’. Thus, in areas in which little is known… exploratory or descriptive work naturally precedes (and informs) randomized field trials, which, incidentally, are meaningless without this foundational work” (p. 114).

These points highlight the appropriateness of a design research approach for exploratory studies.

**The Nature of the Research Questions**

Feuer et al. (2002) noted that the research questions should determine the research method, not the other way around. The research questions of the study matched the questions suggested by Shavelson et al. (2003) as appropriate for design research, specifically: “What is happening?” and “Why or how is it happening?”

**The Nature of the CSM**

The third point supporting the use of design research for this study was the nature of the product that was developed and evaluated. McKenney et al. (2006) noted that curriculum design research can produce three types of outputs: design principles, curricular products or programs, and professional development of the participants involved (pp. 72-73). As will become evident in this dissertation, my study was structured to produce exactly these outputs through the development and evaluation of the CSM.
Alignment with the Key Principles of Design Research

Finally, this study aligned with the four key principles of design research (see Chapter 4): context, use, theory, and collaboration. The study was conducted by a team of practitioners (including the author) in a real world setting to address a practical issue, so it clearly embodied the principles of context, use, and collaboration. The study will also identify relevant design principles particular to the CSM that will potentially contribute to existing curriculum theory regarding the promotion of mathematics teaching as design. A prominent feature of design research is that it can generate design principles that support the transfer of interventions to other settings and guide the development of future innovations (Collins, Joseph, & Bielaczyc, 2004; Nieveen, McKenney, & van den Akker, 2006; Reeves, 2006; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006a). Van den Akker (1999) stated that design principles may take the form of statements such as: “If you want to design intervention X (for the purpose/function Y in context Z), then you are best advised to give that intervention the characteristics A, B, and C…, because of arguments P, Q, and R” (p. 9). The current study attempted to understand the impact of specific features of the CSM in promoting teaching as design, while generating design principles that may be elaborated, tested, and refined through further research beyond this study. Together, these four reasons make a strong case for the appropriateness of employing design research to conduct this study.

Structure of the Study

The research process was conducted according to Reeves’ (2006) model of the design research cycle, as shown in Figure 1.
The iterations of analysis, design, testing, refinement, and reflection that constitute design research require an extended period of time to complete, and design research studies often continue for several years. While I plan to continue with this research as an integral part of my work as Mathematics Supervisor, for the purposes of my dissertation I have completed a modified cycle of Analysis, Development, Testing, and Initial Reflection, tracing the development of one prototype of CSM organized around a single mathematics concept. Figure 2 depicts the four phases of the study using a Gantt chart, and each phase of the study is outlined below.

**Figure 2.** Gantt chart depicting the four phases of the study.
**Phase 1: Analysis.**

During the Analysis phase, the Design Group collaborated to explore, clarify, and define the problem of promoting mathematics teaching as design. Such collaboration is a key component of design research, because, as Herrington (2010, March) noted, practitioners can provide valuable insight into the research problem.

Our work during this phase focused on the development of a common understanding among Design Group members of teaching as a design activity. Actions included the reading and discussion of relevant literature, the sharing of personal experiences of planning and teaching mathematics, and the identification of the essential features of teaching as design. The process and outcomes of this phase are described at the end of Chapter 2.

**Phase 2: Development.**

In the Development phase, the Design Group began by “interrogating the literature” in search of existing theory to inform the design (Herrington, 2010, March) – including the content, organization, and delivery – of the CSM. Recommendations by Ball and Cohen (1996) and M. W. Brown (2009) guided our decisions regarding the organization and delivery of the CSM. The mathematics content decisions were informed by NCTM’s *Principles and Standards for School Mathematics* (2000) and *Curriculum Focal Points* (2006), CCSSO’s *Common Core Standards for Mathematics* (2010), and the Virginia Standards of Learning for Mathematics (2009) as we identified what students should understand about the concept, what teachers need to understand about the concept, and effective ways of teaching the concept and assessing student learning. The Development phase is described in detail in Chapter 5.
This phase also included the development of the instruments that were used in the Testing and Initial Reflection phases of the study. Details regarding instrumentation can be found in the Data Collection section of Chapter 6.

**Phase 3: Testing.**

Once the prototype CSM had been developed, the Implementation Group tested the resources as they planned and taught a 10-day unit of instruction addressing the identified concept. The teachers maintained a planning and teaching log during the pilot unit and then completed a questionnaire at the end of the unit, describing and reflecting upon their experiences.

**Phase 4: Initial Reflection.**

A focus group interview of the Implementation Group, facilitated collaboratively by the lead researcher and the members of the Design Group, was conducted after the completion of the pilot unit. The goal was to understand how the teachers used the CSM, as well as their perceptions of the CSM’s effectiveness in supporting them in engaging in teaching as design. In addition, the interview sought to identify the strengths and weaknesses of the CSM and obtain recommendations for improvement. As the primary data source for evaluating the CSM, the transcription of this interview was analyzed and discussed by the Design Group as part of a second focus group interview.

**Research Team**

I served as the lead researcher and facilitator of a team of practitioners consisting of six elementary classroom teachers and two elementary instructional specialists (EIS) from my school division. Team members served on a volunteer basis and were awarded licensure re-certification points for their work. The eight members were divided into two smaller work groups of four members each: a Design Group and an Implementation Group. The Design
Group, consisting of two classroom teachers and two EIS, was responsible for the design, development, and evaluation of the CSM. The Implementation Group, consisting of four second grade teachers from four different elementary schools, tested the CSM and provided feedback to the Design Group. The work of the Design Group occurred throughout all four phases of study, while the work of the Implementation Group occurred only during the last two phases of the study.

Overview of the Dissertation

Chapter 2 provides a literature review elaborating on the idea of teaching as design and includes a description of the Analysis phase of the study. Chapter 3 contains a literature review establishing the educational leadership functions of the mathematics supervisor. Chapter 4 offers a literature review describing the origins, rationale, and underlying principles of design research, outlines a process for conducting design research, and addresses the challenges associated with this research method. Chapter 5 describes the Development phase of the study and provides a detailed description of the prototype CSM, including the rationale behind the design decisions. Chapter 6 contains the methods used to carry out this study, focusing on data collection and analysis. Chapter 7 describes the outcomes of the Testing and Initial Reflection phases, and the conclusions of the study are contained in Chapter 8.
Chapter 2: Understanding Teaching as Design

The previous chapter provided an introduction to this study and briefly outlined the concept of teaching as design. This chapter examines the theoretical foundation for teaching as design, beginning with the development of a definition of the term “curriculum” and a discussion of the interdependent relationship between curriculum and instruction. A characterization of teachers as decision makers who use, rather than merely implement, curriculum materials is established, leading to a detailed explanation of the concept of teaching as design and its impact on the goals of this study. The chapter concludes with a description of the Analysis phase of the study, including a discussion of the essential features of teaching as design identified by the Design Group for inclusion in the Curriculum Support Materials.

The purpose of this study was to explore the potential for Curriculum Support Materials (CSM) for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design. To justify promoting teaching as design as a possible means for resolving the conflict between curriculum materials and state standards described in Chapter 1, this chapter synthesizes the research literature relevant to understanding teaching as a design activity. I will begin by developing a definition of the term curriculum that will serve as a foundation for the discussion that follows.

Defining Curriculum

Curriculum, although commonly used by teachers, school administrators, policy makers, professors of education, education researchers, and legislators, is in fact a rather nebulous term; it has no clear-cut definition and is open to a wide range of interpretations influenced by individual philosophical beliefs. Toombs and Tierney (1993) noted that “curriculum as a concept, as a discrete idea, is almost without boundaries. It can mean anything from the ‘bundle’
of programs an institution offers to the individual experience of a particular student” (p. 177).

Oliva identified an extensive list of possible interpretations of curriculum, including:

- that which is taught in school;
- a set of subjects;
- content;
- a program of studies;
- a set of materials;
- a sequence of courses;
- a set of performance objectives;
- a course of study;
- everything that goes on within the school, including extra-class activities, guidance, and interpersonal relationships; and
- that which an individual learner experiences as a result of schooling (Oliva, 2009, p. 3).

With such a wide range of possible meanings, it is not surprising that Grumet (1988) described curriculum as “a field of utter confusion” (p. 4).

Portelli (1987) questioned the merits of even attempting to define curriculum, asserting that “curriculum is a complex notion, one that involves elements of such a varied nature that a definition cannot capture its full meaning” (p. 363). He further noted that, while “having a well thought-out and justified curriculum perspective is crucial… this perspective cannot be captured by a straightforward definition because of the very nature of Curriculum….” (p. 366). Toombs and Tierney (1993), however, adopted a more practical approach to this issue, stating that “those who apply the concepts of the curriculum to real situations must first devise a working definition
and then put it into operation” (p. 178). In that spirit, the remainder of this section will consider several prominent conceptions of curriculum in order to develop a definition of the term.

A useful starting point for thinking about curriculum can be found in the work of Ralph W. Tyler. In the 1940’s, Tyler identified four fundamental questions for analyzing curriculum, focusing on purpose, content, organization, and evaluation (Tyler, 1949, p. 1).

In terms of purpose, Tyler (1949) stated that the first step in developing an educational program must be the identification of its goals, because “these educational objectives become the criteria by which materials are selected, content is outlined, instructional procedures are developed and tests and examinations are prepared” (p. 3). In other words, before attempting to create a curriculum, it must first be established what that curriculum is intended to accomplish. Tyler believed that curriculum goals should be stated as behavioral objectives. However, he noted that “other things being equal more general objectives are desirable rather than less general objectives” (p. 57) and that well-written objectives should identify both the desired behavior and the content “in which this behavior is to operate” (p. 47).

In determining curriculum content, Tyler (1949) described a process for moving between a general outline of a field of study generated by subject area specialists to behavioral objectives at the school and classroom levels. To organize the student learning experiences intended to bring about the changes in behavior specified in the curriculum objectives, he stated that curriculum designers must pay attention to issues of continuity, sequence, and integration so that learning experiences will reinforce each other.

The fourth component of Tyler’s model is curriculum evaluation, which he defined as “the process for determining the degree to which these changes in behavior are actually taking place” (p. 106). It’s important to note that the essence of evaluation in his model goes beyond
the assessment of individual student learning, forming the basis of ongoing curriculum development:

What is implied in all of this is that curriculum planning is a continuous process and that as materials and procedures are developed, they are tried out, their results appraised, their inadequacies identified, suggested improvements indicated; there is replanning, redevelopment and then reappraisal; and in this kind of continuing cycle, it is possible for the curriculum and instructional program to be continuously improved over the years.

(Tyler, 1949, p. 123)

Interestingly, Tyler’s emphasis on cyclical improvement parallels the Testing and Refinement phase of design research (see Chapter 4), reinforcing the appropriateness of employing design research to study issues of curriculum.

Although Tyler’s model does not constitute a definition of curriculum, it provides a framework for understanding curriculum as a process rather than an object. This concept will guide the formulation of my definition of curriculum.

In the 1960’s, Taba defined curriculum as “a plan for learning,” noting that “what is known about the learning process and the development of the individual has bearing on the shaping of a curriculum” (Taba, 1962, p. 11). In the 1980’s, Saylor, Alexander, and Lewis defined curriculum as “a plan for providing sets of learning opportunities for persons to be educated” (as quoted in Oliva, 2009, p. 4). At the turn of the century, Foshay stated that “the curriculum is best thought of as a plan for action by students and teachers” (Foshay, 2000, p. xv). Despite having been offered over a period of nearly forty years, these three definitions are essentially equivalent, focused on planning for learning. It is not surprising, then, that Oliva’s recent definition reflects the same basic idea: “A plan or program for the learning experiences
that the learner encounters under the direction of the school” (Oliva, p. 16). Wiggins and McTighe (2005) offered a similar definition, adding an emphasis on student performance: “….curriculum refers to the specific blueprint for learning that is derived from desired results….

It is a map for how to achieve the ‘outputs’ of desired student performance…” (pp. 5-6). Each of these authors narrowed the concept of curriculum to a straightforward premise, avoiding issues of political and philosophical interpretation, to create a practical definition of this elusive term.

Because of their similarities, choosing among the prominent definitions listed above is essentially a matter of preference. I prefer Foshay’s (2000) characterization of curriculum as a plan for action by students and teachers because of its simplicity and its emphasis on action for students as well as teachers, which seems particularly appropriate for mathematics. However, Foshay’s definition does not capture Tyler’s idea of curriculum as a process, nor does it capture Wiggins and McTighe’s emphasis on student performance. So, I define curriculum as a continuously evolving plan for action by students and teachers to produce desired student learning.

**Relationship Between Curriculum and Instruction**

It is also important to clarify the relationship between curriculum and instruction. The simplest approach is to think of “curriculum as that which is taught and instruction as the means used to teach that which is taught… the ‘what’ and… the ‘how’” (Oliva, 2009, p. 7). However, this approach implies that curriculum and instruction are mutually exclusive and fails to capture the interactions between the two. Oliva (2009) addressed this issue by offering a cyclical model as one way of describing the relationship, shown in Figure 3.
Figure 3. Oliva’s Cyclical Model of the curriculum-instruction relationship (Oliva 2009, p. 10).

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Oliva placed curriculum in the first circle to indicate his belief that curriculum decisions should precede instruction, while the arrows highlight their interdependence. He asserted that curriculum and instruction inform each other in a process that is “continuous, repetitious, and never-ending” (p. 10). Oliva further identified three common beliefs among current curriculum theorists:

- Curriculum and instruction are related but different.
- Curriculum and instruction are interlocking and interdependent.
- Curriculum and instruction may be studied and analyzed as separate entities but cannot function in mutual isolation. (Oliva, 2009, p. 11)

The cyclical model and these common beliefs match my own perspective on curriculum developed through my experiences as a classroom teacher and curriculum supervisor: the curriculum guides instruction, but instruction, in turn, must provide feedback to improve the curriculum.

An additional perspective on the relationship between curriculum and instruction can be gained from an examination of the Principles and Standards for School Mathematics published
by the National Council of Teachers of Mathematics (NCTM) (2000). The six Principles are intended to guide teachers and administrators as they make decisions about “the content and character of school mathematics” (p. 11) and, not surprisingly, one of the principles addresses Curriculum and one addresses Teaching. The Curriculum Principle focuses on identifying important mathematics and articulating topics across the grade levels (which is clearly in line with Tyler’s views on content and organization), but the interdependence between curriculum and instruction is highlighted in the Teaching Principle, which states, in part, that teachers must understand what their students need to learn. Further cross-referencing of curriculum and instruction occurs within the elaborations of these two principles: Under the Curriculum Principle, the authors note that “teachers need to be able to adjust and take advantage of opportunities to move lessons in unexpected directions” (p. 15), while under the Teaching Principle they state that teachers must have “deep flexible knowledge about curriculum goals and about the important ideas that are central to their grade level” (p. 17). That the authors of this foundational document of mathematics teaching and learning felt compelled to use the ideas of curriculum and instruction to describe each other provides a poignant illustration of the inherent connections between curriculum and instruction.

**Teachers as Decision Makers**

The notion of curriculum as a continuously evolving plan that is inextricably linked with instruction paves the way for a re-conceptualization of teacher practice. As Oliva’s model (see Figure 3) makes clear, the relationship between curriculum and instruction (and, therefore, the relationship between curriculum developers and teachers) is not a one-way street in which curriculum prescribes instruction. Consequently, it is inaccurate to view teachers simply as
implementers of curriculum. This section makes a case for characterizing teachers as decision makers.

The impact of individual teachers on student achievement has been well documented in the literature (Marzano, 2000; Miller, 2003; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004). The bottom line is that “teachers make a difference” (Wright, Horn, & Sanders, 1997, p. 57). As Marzano (2003) noted, “regardless of the research basis [under consideration], it is clear that effective teachers have a profound influence on student achievement and ineffective teachers do not” (p. 75). Marzano (2000) also identified curriculum design (“…the order and pacing of content and instructional activities” [p. 63]) as one of three teacher-level variables that impact student achievement. These findings suggest that the ways in which teachers use curriculum materials to plan and deliver instruction have an impact on student achievement. As Valverde, Bianchi, Wolfe, Schmidt, and Houang (2002) pointed out, since teachers bear the primary responsibility for implementing curricular goals, “understanding teachers’ instructional behaviors is necessary to characterize educational opportunities” (p. 167).

Shulman (1990) asserted that “the essential value of curriculum is how it permits teachers to adapt, invent and transform as they confront the realities of classroom life” (p. vii) and that “teachers must be prepared to serve as acute critics, analysts and adaptors of curriculum” (p. viii). Adaptation of curriculum by teachers results in what Ball and Cohen (1996) referred to as the “enacted curriculum… jointly constructed by teachers, students, and materials in particular contexts” (p. 7). So, while curriculum can be defined as an evolving plan for action, variations in teacher implementation of that plan can produce differences between the intended curriculum and the achieved curriculum (McKnight et al., 1987; National Research Council, 2004). The original intentions of curriculum designers are transformed through teachers’ use of the
curriculum materials, so that, as Shulman (1990) noted, “the real curriculum is that experienced in classrooms, not the published texts and teachers’ manuals” (p. vii). Lloyd, Remillard, and Herbel-Eisenmann (2009) used this “distinction between the written and enacted curriculum as a starting point” (p. 5) for their text on mathematics teachers’ use of curriculum materials, which, to date, is the only published compilation of research specific to this issue.

Shulman (1986) delineated “pedagogical content knowledge” and “curricular knowledge” as important components of teacher knowledge that are separate from subject matter content knowledge. He described pedagogical content knowledge as “the ways of representing and formulating the subject that make it comprehensible to others” (p. 9), emphasizing that teachers must know not only their subject matter, but also methods for overcoming the common barriers and challenges students face in learning the content. He also asserted that teachers must possess “understandings about the curricular alternatives available for instruction” (p. 10), and Grossman positioned this idea of curricular knowledge as a component of pedagogical content knowledge that includes “knowledge of curriculum materials available for teaching particular subject matter, as well as knowledge about both the horizontal and vertical curricula for a subject” (as quoted in Roth McDuffie & Mather, 2009, p. 305). Peterson, Fennema, Carpenter, and Loef (1989) noted the importance of teachers’ beliefs, stating that “teachers’ pedagogical content beliefs and teachers’ pedagogical content knowledge may be importantly linked to teachers’ classroom actions and, ultimately, to students’ classroom learning in mathematics” (p. 36). Ernest (1989) asserted that teachers’ subject matter beliefs and conceptions “have a powerful impact on teaching through such processes as the selection of content and emphasis, styles of teaching, and modes of learning” (p. 20). The importance of pedagogical content knowledge and beliefs in shaping teachers’ actions confirms the role of teachers as decision makers.
Ben-Peretz (1990) developed the concepts of “curriculum potential” and “curriculum interpretation” to frame an analysis of teacher-curriculum interaction, describing the connections between curriculum materials, curriculum potential, and teachers’ interpretations of curriculum as follows:

Curriculum materials are the ‘texts’ used by teachers in their daily professional lives… [that] may be read and interpreted in different ways. The central idea… is that curriculum materials… are more than the embodiment of their developers’ intentions, and offer teachers a wide array of curriculum potential depending on their purposes and the demands of their classroom situations. Teachers need knowledge and expertise in uncovering the potential of curriculum materials so that these can be reconstructed for particular students and for specific classroom situations. (p. xiii)

Ben-Peretz asserted that curriculum materials possess educational potential beyond their stated goals and objectives, because teacher interpretation of curriculum materials is a fundamental aspect of teaching that results in uses of the curriculum materials that go beyond the intentions of the developers. She distinguished such “disclosing of curriculum potential” from unintended outcomes of instruction, asserting that disclosure of curriculum potential is an intentional outcome resulting from deliberate and skillful teacher interpretation of curriculum materials.

Taken together, these works by Shulman (1986), Peterson et al. (1989), Ernest (1989) and Ben-Peretz (1990) establish a view of teachers as decision makers who evaluate and interpret curriculum materials to plan and deliver instruction.

**Use Versus Implementation**

It is necessary to emphasize the significance of the term *use* in the context of teachers and curriculum materials. Lloyd et al. (2009) selected the term *use* instead of the more commonly
used term *implementation* to guide their work on teacher-curriculum interaction in mathematics. In other contexts, these two terms are typically used interchangeably, but these authors identified two problems with the idea of teachers’ implementation of curriculum materials:

First, it assumes that embedded in these resources is everything a teacher would need to enact the curriculum precisely as envisioned by the designers. Second, this view of implementation suggests that the process of putting the ideas captured in previously designed curriculum materials into practice is a straightforward one and does not involve substantial engagement, interpretation, and decision-making on the part of the teacher. (Lloyd et al., 2009, pp. 7-8)

Distinguishing *use* from *implementation* emphasizes the role of teachers as decision makers and parallels the concept of curriculum as a continuously evolving plan for action as previously discussed.

**Teaching as Design**

The view of teachers using, rather than merely implementing, curriculum materials to plan and deliver instruction supports the conceptualization of teaching as design. Similarly to the way that Collins (1992) depicted education research as a design science (see Chapter 4), M. W. Brown and Edelson (2003) argued that teaching is also a design activity, because “teachers must perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance tradeoffs and devise strategies – all in the pursuit of their instructional goals” (p. 1). This conception of teaching corresponds with the ideas of Stepanek, Leong, Griffin, and Lavelle (2011) and Wiggins and McTighe (2005) and is in line with the research discussed previously in this chapter (Ben-Peretz, 1990; Lloyd et al., 2009; Peterson et al., 1989; Shulman, 1986) characterizing teachers as decision makers.
M. W. Brown and Edelson (2003) based their argument for teaching as design on their review of cognitive research into the interactions between people and tools, identifying three key ideas related to teaching as design:

a) Curriculum materials play an important role in affording and constraining teachers’ actions;

b) Teachers notice and use such artifacts differently given their experience, intentions and abilities;

c) Teaching by design is not so much a conscious choice but an inevitable reality. (p. 1)

The first idea, that curriculum materials afford and constrain teachers’ actions, is based on the work of James Wertsch (1998), who described an “irreducible tension” between people and their tools. Wertsch used a pole vaulting analogy to make his point:

…it is futile, if not ridiculous, to try to understand the action of pole vaulting in terms of the mediational means--the pole--or the agent in isolation. The pole by itself does not magically propel vaulters over a cross bar; it must be used skillfully by the agent. At the same time, an agent without a pole or with an inappropriate pole is incapable of participating in the event. (Wertsch, 1998, p. 27)

To apply this analogy to teaching, it would be futile to attempt to understand the action of teaching in terms of teachers or curriculum materials in isolation.

The concepts of *affordance* and *constraint* require some elaboration. M. W. Brown (2009) described these as “two sides of the same coin” (p. 20) with affordances representing the ways in which curriculum materials suggest their possible uses, and constraints representing the ways in which curriculum materials “help to define an instructional space” (p. 21). For example, curriculum materials typically contain lesson plans indicating instructional objectives, necessary
prior knowledge for students, content information for teachers, student activities, suggestions for differentiating instruction, and instruments for assessing student learning – all of which can be considered affordances that suggest how the curriculum materials might be used. In addition, curriculum materials may also provide what M. W. Brown (2009) referred to as “parameters,” such as how to organize the classroom’s physical space, recommendations for grouping students, and recommended allotments of time for each component of the lesson – all of which can be considered instructional constraints. Curriculum materials also constrain instruction in terms of the content that the authors chose to include and to omit from the resources. It should be noted, however, that M. W. Brown did not consider such constraints to be inherently negative, noting instead that they help “to provide meaning and coherence within an otherwise enormous range of instructional possibilities” (p. 21).

The second idea offered by M. W. Brown and Edelson related to teaching as design, that teachers use curriculum materials differently given their experience, intentions and abilities, is supported by the work of Ball and Cohen (1996) regarding the difference between the written and enacted curriculum and the work of Peterson et al. (1989) regarding the importance of teachers’ pedagogical content beliefs in shaping teachers’ actions, as previously discussed.

M. W. Brown and Edelson did not offer explicit justification of their third idea, that teaching by design is an inevitable reality, apparently considering it to be self-evident. While it is reasonable to be skeptical of this lack of supporting evidence, I am willing to accept this assertion as a reasonable conclusion that is supported by the arguments already developed throughout this chapter.

The idea of teaching as design was also supported by Wiggins and McTighe (2005), who explicitly stated: “Teachers are designers. An essential act of our profession is the crafting of
curriculum and learning experiences to meet specified purposes” (p. 13). These authors noted that, as a principle of good instructional design, form should follow function, emphasizing the importance of “backward” planning from student learning goals as a key element of teaching as design.

The concept of teaching as design is captured nicely in the following statement by M. W. Brown (2009):

When teachers use curriculum materials to craft instructional episodes in order to achieve goals, when they use materials as tools to transform a classroom episode from an existing state to a desired one, they are engaging in design – whether or not they intend to do so.

Whether teachers modify an existing set of materials or integrate them in a literal manner, they are engaging in the sort of goal-directed activity I am calling design. (p. 23)

This positioning of teachers as designers and curriculum materials as tools aligns with other research (McClain et al., 2009; Stein & Kim, 2009) and matches my experiences as a classroom teacher and curriculum supervisor: Teaching is a design activity.

**Brown’s Design Capacity for Enactment framework.**

To develop a more complete picture of teaching as design, M. W. Brown (2009) argued that it is necessary to understand the features of the curriculum materials as well as the personal capacities that teachers bring to their interaction with the materials. He offered a Design Capacity for Enactment (DCE) framework depicting these relationships, shown in Figure 4.

The left-hand side of the DCE framework represents the features of curriculum materials, including physical objects (instructional materials), domain representations (how the content is organized and explained), and procedures (instructional tasks). The right-hand side represents the personal capacities of teachers, including subject matter knowledge, pedagogical content knowledge, and goals and beliefs (note that these teacher capacities are the same as those previously discussed from the works of Shulman [1986], Grossman [as quoted in Roth McDuffie & Mather, 2009, p. 305], and Peterson et al. [1989]). The center of the DCE framework represents the ways in which teachers use curriculum materials to design instruction and indicates that the interaction between teachers and materials produces instructional outcomes.

The DCE Framework identifies three types of teacher use of curriculum materials: offloading, adapting, and improvising. These teacher actions are central to the idea of teaching as design, and each will be addressed in turn. It should be noted that, although these ideas arose
from research that was conducted on teachers’ use of science materials, I agree with M. W. Brown’s assessment that “the analysis is relevant to mathematics” (2009, p. 34).

The concepts of offloading, adapting, and improvising are best understood as a “scale” (M. W. Brown, 2009) or spectrum of responsibility for guiding instruction (M. W. Brown used the term “agency” instead of “responsibility”). At one end of the spectrum, offloading refers to teachers’ literal use of the curriculum materials, placing the responsibility for guiding instruction directly with the materials. At the other end of the spectrum, improvising refers to teachers’ use of their own instructional strategies to reach the instructional goal. By intentionally deviating from the strategies indicated in the curriculum materials, the teacher assumes the responsibility for guiding instruction. In the middle of the spectrum, adapting refers to situations where teachers make adjustments to the strategies recommended in the curriculum materials, resulting in a sharing of the responsibility for guiding instruction between the teacher and the materials. It is important to note that teachers may offload, adapt, and improvise multiple times within the same lesson. To demonstrate each type of use, the author used examples from his study of middle school science teachers; instead, I will provide examples from my own teaching to illustrate the applicability of these concepts to mathematics.

In a fourth grade lesson reviewing basic fraction concepts, the curriculum program provided a warm-up activity using pattern blocks to demonstrate representation of fractions and mixed numbers by adding a series halves to the original model (\(\frac{1}{2}, \frac{2}{2}, \frac{3}{2}, \frac{4}{2}, \frac{5}{2}\) etc.). Based on my recent assessment of my students’ understanding of fractional concepts, I decided that, at this point, they needed additional experience with part-whole representations more than with mixed number representations, so I adapted the activity to have them identify fractional parts of different wholes (e.g., “If the hexagon is worth 1, what is the triangle worth? What would the
triangle be worth if the trapezoid was worth 1?”). This adaptation still addressed the primary objective of the lesson, which was stated in the teacher’s guide as “To review fractions as parts of a whole.” In the second part of the lesson, students worked independently to identify fractional parts using pictures of pattern blocks and number lines. I believed that this activity was appropriate for approximately two-thirds of my students, but that the other third was likely to struggle with the task, so I offloaded the planned activity exactly as written for the larger group of students, but pulled the smaller group to work directly with me. Instead of using the pattern block and number line models with the smaller group, I conducted an improvised lesson using Cuisenaire Rods to model equivalent fractions. Note that, although this was an improvisation, it was not a spur-of-the-moment decision; I had planned this small-group activity ahead of time, intentionally shifting the instructional goal based on my knowledge of my students’ understandings and selecting a different instructional model to support my long-term curricular goals. For the third part of the lesson, I improvised a whole-class activity comparing fractions on a number line through a game I called “Closer to 0 or Closer to 1?” Finally, I offloaded the homework assignment, using it for all students, exactly as written.

M. W. Brown (2009) stressed that the scale of offloading, adapting, and improvising is not intended to indicate teacher proficiency, noting that all teachers may rely on each type of use at different times and for different purposes:

Just as a novice teacher might offload instructional responsibility to a scripted lesson due to limited understanding of the subject matter, so might an expert teacher offload instructional responsibility to a worksheet that supports her goals, freeing her to roam the room and respond to student needs as they arise. (p. 25)
He also pointed out that the scale does not measure “fidelity to designer intent” (M. W. Brown, 2009, p. 25), since strict offloading can result in unintended outcomes and improvisation can result in outcomes that are directly in line with the designers’ intent.

**Impact on the Study**

Coming to understand teaching as a design activity, including the characterizations of teachers as decision makers and curriculum materials as tools, had significant implications for me, both as a curriculum supervisor and as a researcher. As M. W. Brown (2009) asserted:

> Understanding how teachers appropriate curriculum artifacts within their daily craft can help curriculum and professional development designers create materials that are more useful to teachers and professional learning experiences that support them in using these materials to meet their goals. (p. 26)

Applying this knowledge of how teachers use curriculum materials to the development of resources intended to support teachers in designing and delivering their mathematics instruction appeared to me to have strong potential for resolving the conflict between the curriculum program and the state standards described in Chapter 1. In addition, the prospect of working with a team of practitioners to study a possible solution to this real-world problem would be directly aligned with the design research principles of context, use, and collaboration (see Chapter 4). Consequently, I chose to structure my dissertation as a design research study focused on the development and evaluation of Curriculum Support Materials (CSM) to promote teaching as design (see Chapter 5).

**Phase 1: Analysis**

As outlined in Chapter 1 and described in detail in Chapter 4, the Analysis phase is the first step of the design research process, in which the researcher collaborates with practitioners to
define the research problem. For the Analysis phase of this study, I collaborated with the Design Group\(^6\) (DG) of my research team, which consisted of two 4\(^{th}\) Grade classroom teachers and two Elementary Instructional Specialists (see Chapter 6), over a period of seven weeks. We held three face-to-face meetings and used an online workspace and email to communicate throughout this phase. Together, we explored and clarified the problem of promoting mathematics teaching as design, working to identify the essential features of teaching as design to be included in the CSM.

Our first task was to develop a common understanding of teaching as design (see Appendix C for the agenda from our first meeting), so we began our work by reading M. W. Brown’s “The Teacher-Tool Relationship” (2009) and the opening chapters of *Understanding by Design* (Wiggins & McTighe, 2005) and *Teaching by Design in Elementary Mathematics, Grades 2-3* (Stepanek et al., 2011).

These readings and our subsequent conversations contributed to our collective knowledge of teaching as design, which is consistent with the ideas of McKenney et al. (2006), who noted the potential “contribution made by design research activities themselves to the professional development of participants” (p. 72). As Elementary Instructional Specialist #1 (EIS1) observed, “We realized that we were already using many of these ideas in our teaching, but reading and talking about them helped give names to those ideas, and it was helpful to reflect on when we do them and why.”

Two aspects of teaching as design resonated with the group and emerged as the focus of our second meeting, which took place one month into the Analysis phase. The first was the idea that different teachers use the same resources differently. Classroom Teacher #1 (DGT1)

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\(^6\) Please note that each time I refer to the Design Group in the remainder of this chapter I am including myself as a member, unless otherwise noted.
commented that, “This is something that can be easily noticed in our daily lives. Although my teaching partner and I use similar resources and tools, we use them in a completely different way” (Online Workspace Comment, 2/15/11). Classroom Teacher #2 (DGT2) agreed: “I feel that at our school our whole 4th grade team uses many of the same resources, but we all get our point across differently yet successfully” (Online Workspace Comment, 2/19/11). This was particularly relevant to me in terms of the conflict in our district between the curriculum program and the state standards: The DG members had noticed that, even when teachers attempt to adhere to the program as written, it is unlikely that any two teachers actually use all of the resources in the same way. This struck me as a potentially useful point to make when encouraging teachers to adopt a design approach.

The second aspect of teaching as design important to the DG was the idea of planning backward from learning goals (what Wiggins and McTighe (2005) referred to as “backward design”). DGT1 provided an effective analogy for understanding backward planning:

When building a building, one doesn’t just start putting bricks on top of each other hoping for a positive outcome. Instead one carefully plans what the end result will be. When designing a lesson, instead of designing the resources first, teachers should consider the goals of what they are trying to accomplish to create a desired outcome using a variety of tools and resources. (Online Workspace Comment, 2/15/11)

This point was also relevant to the program-standards conflict, because it indicates a need for teachers to reflect on their learning goals before selecting lessons, and raises questions about the wisdom of choosing to teach a unit or a lesson simply because it comes next in the curriculum program. DGT2 felt that, “If we took the time for reflecting [on our learning goals] more, we would be more effective teachers” (Online Workspace Comment, 2/19/11).
Although our examination of these resources helped us develop a shared understanding of teaching as design, we were overwhelmed by the massive amount of information contained in these readings (over 600 pages, combined). We found *Understanding by Design* to be a helpful resource, but the book is 325 pages long and devotes a total of three pages (the last three, in the Afterword) to the specifics of getting started with teaching as design (Wiggins & McTighe, 2005, pp. 322-325). Instead, the authors stated that they “have found that an array of scaffolds – prompts, organizers, ideas sheets, and examples – help educators produce higher-quality designs. A full set of these resources is available in the *UbD Professional Development Workbook*" (p. 29). This *Workbook* (2004) is itself nearly 300 pages long and it is just one of several ancillary materials the authors have published regarding teaching as design, including the *UbD Handbook* (1999), *UbD Study Guide* (2000), and the *UbD Guide to Creating High-Quality Units* (2011).

We were similarly overwhelmed by the way that *Teaching by Design in Elementary Mathematics, Grades 2-3* (239 pages) utilizes fourteen 90-minute professional development sessions to produce a single lesson.

Based on our personal experiences delivering and participating in teacher professional development, we believed that presenting even one of these resources to teachers in its entirety would be unlikely to result in significant changes in teacher practice. As DGT2 commented, “If you handed me a huge book [for professional development], it would go straight to my shelf and start gathering dust” (Design Group Meeting, 3/3/11).

To address this challenge, we chose to employ the idea of planning backwards in our own work: Building on the conversations of our second meeting, we spent the next three weeks distilling the readings down to five essential components of teaching as design, asking ourselves, “What are the most important things that we want teachers to understand about teaching as
design?” Our decisions were guided by a desire for simplicity and practicability; the goal was to help teachers see teaching as design as “just good teaching” that would not require drastic changes in their behaviors. The features we identified are discussed in the following section.

Before proceeding to that discussion, however, it is necessary to mention our decision regarding the delivery of the CSM. The findings of the needs assessment (2010) indicated that our district’s teachers preferred online access to curriculum resources. We had two options for providing the CSM online, either through the district’s course management system or through the district’s web site. The DG elected to use the website over the course management system, because the course management system has a poor reputation among teachers in our district and we were concerned that this might cause some teachers to react negatively to the CSM. In addition, the course management system is password-protected, which raised a concern among DG members that the need to log in to the site might inhibit teachers’ use of the CSM. The web site format would also allow us eventually to link the CSM to existing resources so that teachers could access the CSM as part of their regular use of the district site. Our aim was to provide “‘just in time’ online professional development” with “navigation processes [that were] clear, appropriate to the content and easy to use,” as recommended in the Southern Regional Education Board’s (2004, p. 4) e-Learning Process Standard for Design. Our development of the CSM web site is detailed Chapter 5; complete screen captures of the web site can be found in Appendix D.

**Essential features of teaching as design.**

The DG identified five features that we considered essential for helping teachers understand teaching as design:

1) Planning backward from learning goals.

2) Selecting assessments before lessons.
3) Reviewing available resources.

4) Matching instruction to goals and assessments.

5) Using ongoing formative assessment to guide instruction.

The features are ordered to provide a series of actions that a teacher could follow when designing a unit of instruction, although several of the actions would recur throughout the unit. Each feature and the rationale for its inclusion in the CSM will be discussed in turn. Relevant screen captures from the CSM web site are provided in Figures 5-9.

**Essential Feature #1: Planning backward from learning goals.**

This idea is the central theme of the work of Wiggins and McTighe (2005):

Deliberate and focused instructional design requires us as teachers and curriculum writers to make an important shift in our thinking about the nature of our job. The shift involves thinking a great deal, first, about the specific learnings sought, and the evidence of such learnings, before thinking about what we, as the teacher, will do or provide in teaching and learning activities. (p. 14)

This feature was listed first not only because it provides a starting point for designing instruction, but because the DG felt that planning backward forms the heart of teaching as design. We found it to be a straightforward concept that would be easy for teachers to understand, but one that has profound implications for teachers’ subsequent instructional decisions. As Mathematics Supervisor, I believed that helping teachers appreciate the need for planning backward could provide the foundation for addressing the program-standards conflict by motivating teachers to consider how a unit or lesson in the curriculum program actually addresses their instructional goals before deciding to teach it. Figure 5 displays the “Planning Backward from Your Learning Goals” section of the CSM web site.
The Essential Features of Teaching as Design

1. Planning Backward from Your Learning Goals

To begin with the end in mind means to start with a clear understanding of your destination. It means to know where you’re going so that you better understand where you are now so that the steps you take are always in the right direction.

- Stephen Covey, The 7 Habits of Highly Effective People (1989)

The first essential feature of teaching as design is deceptively simple: plan backward. This is an effective strategy for reaching any goal in life and it can be especially useful for teachers in reaching their instructional goals; however, it can be surprisingly challenging to establish those goals, especially in mathematics.

The Virginia Standards of Learning for Mathematics provide a nice list of the things that students should know and be able to do, but they aren’t very helpful when it comes to the things that students should understand. If we focus our instruction only on the Standards of Learning, we run the risk of producing students who can “do” lots of things, but who don’t understand how those things work or why we wanted them to learn how to do them in the first place. Recent national and international test results support the idea that being proficient with skill-based standards like our SOL does not necessarily translate to understanding mathematics.

Instead, we want to help teachers begin their planning by considering:

- What are the big ideas of elementary mathematics that I want to address?
- What do my students need to understand about those big ideas?
- What do they need to know and be able to do?

We believe that, if we can help teachers connect the Standards of Learning to the big ideas, it will help students develop the conceptual understandings that give meaning to the facts they know and the procedures they can do. We think this might be a better way to develop students who approach problem-solving like this.

ASCD Article: Backward Design for Forward Action by Wiggins and Thomas

Essential Feature #2: Selecting assessments before lessons.

This feature of teaching as design is a logical extension of planning backward: Once we have established our learning goals, how will we decide whether or not our students have achieved those goals? As Wiggins and McTighe (2005) asked, “What will we accept as evidence of student understanding and proficiency?” (p. 18).
The DG agreed with the way that Wiggins and McTighe emphasized the importance of identifying assessments before planning learning experiences (e.g., see 2005, p. 22). In terms of the program-standards conflict, we believed that asking teachers to select assessments before selecting lessons could help them ensure that the subsequent learning experiences that they chose to provide would help their students achieve the desired results; having clearly-defined goals, and assessments that measure students’ progress toward those goals, is prerequisite to being able to evaluate learning experiences. We felt this was a crucial step toward beginning teaching as design.

The goal of this section of the CSM web site (see Figure 6) was to introduce this relatively simple idea while opening the door for future professional development about the uses of different types of assessments, including ongoing formative assessment (Essential Feature #5).

**Figure 6.** CSM web site screen capture: Getting Started – Essential Feature #2.

2. **Selecting Your Assessments First**

   How will we know if students have achieved the desired results? What will we accept as evidence of student understanding and proficiency?


   This idea may represent a significant shift from your current practice, but it's a logical extension of planning backward: Once you've decided what you want your kids to learn, how will you decide if they've learned it? This is a key step in aligning your instruction with your goals.

   We want to help teachers begin to use assessments that provide evidence of students' proficiency with the SOL as well as their understandings of the big ideas.

   Wiggins & McTighe’s [Types of Evidence](#)
   Dan Mulligan’s [Checklist for Assessment Development](#)

**Essential Feature #3: Reviewing available resources.**

This feature of teaching as design served as the centerpiece of our efforts to address the program-standards conflict by shifting teachers away from being implementers of a curriculum program and toward becoming decision makers who use curriculum materials as tools. Guided
by the research discussed earlier in this chapter (Ben-Peretz, 1990; M. W. Brown, 2009; M. W. Brown & Edelson, 2003; McClain et al., 2009; Stein & Kim, 2009), in this section of the CSM web site (see Figure 7) we directly stated the need for teachers to evaluate curriculum materials. Our goal was to employ a conversational tone to express this idea simply and unequivocally.

**Figure 7.** CSM web site screen capture: Getting Started – Essential Feature #3.

<table>
<thead>
<tr>
<th>3. <strong>Reviewing Available Resources</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers must perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance tradeoffs and devise strategies - all in the pursuit of their instructional goals.</td>
</tr>
</tbody>
</table>


"Wait - you mean I don't just teach the program?"

Yes, that's what we're saying. We believe that teachers are decision-makers who use curriculum materials as tools to meet their goals. Our new math program is great, but implementing it mechanically will not get the job done.

Our job is to teach the SOL (it's the law), and now we've added a focus on teaching big ideas to help students better understand the SOL; teachers need the freedom (and the ability) to evaluate and select instructional resources in order to craft learning experiences that will help our students reach these goals.

**Essential Feature #4: Matching instruction to goals and assessments.**

This feature is so similar to the previous feature (reviewing available resources) that, at first glance, it may not appear to warrant distinction from Essential Feature #3. However, the DG felt it was useful to include this step in order to emphasize the ongoing nature of teaching as design (see Figure 8). We wanted teachers to understand that it is important to evaluate lessons and activities throughout a unit of instruction, not just during the initial planning. This reminder to match their instruction to their goals and assessments was intended to be a link from the idea of reviewing available resources to the idea of using ongoing formative assessment, which is the final essential feature of teaching design, described in the next section.
Essential Feature #5: Using ongoing formative assessment to guide instruction.

The final essential feature of teaching as design identified by the DG was the use of ongoing formative assessment to guide instruction. NCTM provided the following succinct definition of formative assessment: “Formative assessment is any assessment task designed to promote students’ learning. …Formative assessment is different from summative assessment, the goal of which is to measure mastery” (2007, p. 1). The use of formative assessments as part of an overall assessment plan is supported by Wiggins and McTighe (e.g., see 2005, pg. 153) and Tomlinson (e.g., see 2007/2008), as well as by NCTM’s Assessment Principle: “Assessment should be more than merely a test at the end of instruction to see how students perform under special conditions; rather, it should be an integral part of instruction that informs and guides teachers as they make instructional decisions” (NCTM, 2000). Our goal in this section of the CSM web site (see Figure 9) was not to provide in-depth coverage of this topic, but rather to introduce the idea of using informal assessment strategies that provide “both teachers and students with feedback, so that teaching and learning activities can be altered according to the results” (NCTM, 2007, p. 1). The DG felt that the use of ongoing formative assessment was an essential feature of teaching as design because it can serve as a catalyst for continuously re-
evaluating available resources (Essential Feature #3) in order to match instruction to the established goals and assessments (Essential Feature #4).

**Figure 9.** CSM web site screen capture: Getting Started – Essential Feature #5.

<table>
<thead>
<tr>
<th>Formative Assessment</th>
<th>Summative Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>When?</strong></td>
<td>During</td>
</tr>
<tr>
<td><strong>Typically Graded?</strong></td>
<td>No</td>
</tr>
<tr>
<td><strong>Purpose?</strong></td>
<td>Guiding Instruction</td>
</tr>
<tr>
<td><strong>Who’s it for?</strong></td>
<td>Teachers and Students</td>
</tr>
</tbody>
</table>

The simplest way to understand the difference between formative and summative assessment is to think of formative assessment as "assessment for learning" and summative assessment as "evaluation of learning." Using formative assessments allows you to check your bearings throughout your instruction to help you stay on the course you've set.

Think of it as progress monitoring for yourself: "Are my students learning what I think they are?" Formative assessment gives you time to adjust your instruction.

NCTM Research Clip: **What is formative assessment?**
NMSA Article: **Formative and Summative Assessments in the Classroom**
ASCD Article: **Learning to Love Assessment** by Carol Ann Tomlinson

Taken together, we believed these five features would provide enough information about teaching as design without overwhelming our teachers. We also felt that we had taken the massive amount of available information and successfully distilled it down to five steps that we would be comfortable using to talk with teachers about teaching as design: 1) Decide what you want your students to learn; 2) Decide how you’ll know if they’ve learned it; 3) Evaluate your resources so you can 4) Match your instruction to your goals; and 5) Monitor your students
progress along the way so you can change your instruction as needed. Our hope was that the CSM web site would offer teachers a safe starting point for their journey into teaching as design.

Summary

This chapter provided a theoretical foundation for teaching as design and described the Analysis phase of the study, including the development of the Teaching as Design sections of the CSM web site and the identification of the five essential features of teaching as design. Chapter 3 will examine the role of the mathematics supervisor as an educational leader.
Chapter 3: The Mathematics Supervisor

Chapters 1 and 2 introduced the study and provided a theoretical foundation for the concept of teaching as design. This chapter reviews the literature regarding educational leadership, identifies three central functions of the mathematics supervisor, and presents the model for mathematics curricular leadership used to guide this study. The chapter begins with a discussion of the impact of educational leadership on student achievement and an examination of current standards, performance expectations, and performance indicators for educational leadership to identify the central functions of the mathematics supervisor. The model for mathematics curricular leadership is then described, focusing on the leadership actions of Curriculum Implementation and Supporting Curriculum Use as they apply to promoting teaching as design.

I have various responsibilities (see Appendix E) as a district mathematics supervisor, but my overall goal is simple: Promote student achievement in mathematics. I perform three primary leadership functions in pursuit of this goal: developing and implementing curriculum; delivering professional development; and using assessment data to inform instruction and guide program evaluation. This chapter reviews the relevant literature regarding mathematics educational leadership to establish a rationale for these leadership functions. I will begin with a discussion of the significant impact that educational leadership has on student achievement.

Impact of Educational Leadership on Student Achievement

In a 2004 research review, Leithwood, Louis, Anderson, and Wahlstrom found that “leadership is second only to classroom instruction among all school-related factors that contribute to what students learn at school” (p. 5). The authors also found that effective leadership is essential to improving struggling schools, noting that they found “virtually no
documented instances of troubled schools being turned around without intervention by a powerful leader” (p. 5).

While the vast majority of research relating educational leadership to student achievement has focused on principals and superintendents, the term “educational leader” has broadened over the last decade to include other roles. In their *Performance Expectations and Indicators for Educational Leaders*, the Council of Chief State School Officers (CCSSO) (2008b) stated that performance expectations “extend beyond school administrators to include those who have responsibility for and exert influence over the education system at all levels... [including] curriculum supervisors… and professional development providers” (p. 10). My position as a district mathematics supervisor is clearly encompassed within this portrayal of educational leadership.

Leithwood et al. (2004) identified twelve district-level actions that improved student learning, including “develop/adoption of district-wide curricula” and “alignment of curriculum, teaching and learning materials, and assessment with relevant standards” (p. 42). In a meta-study of school districts that have been successful in closing the achievement gaps among diverse groups of students (including students in racial, low-SES, and special education subgroups), Leithwood (2010) found evidence that “district-wide approaches to curriculum and instruction” and providing “job-embedded professional development” were common characteristics of successful districts (p. 249). As I noted above, establishing a district-wide curriculum aligned with assessment standards and providing professional development to support teachers in delivering instruction to meet those curriculum standards are two of my primary responsibilities as Mathematics Supervisor. These research findings highlight the importance of
educational leadership – in particular, the potential that district-level administrators have for supporting student achievement.

**Standards for Educational Leadership**

In 2008, CCSSO published *Educational Leadership Policy Standards: ISLLC 2008*, a “broad set of national guidelines… [that] provide high-level guidance about the traits, functions of work, and responsibilities” (p. 5) of educational leaders. This document (hereafter referred to as *ISLLC*\(^7\) 2008) was a revision of CCSSO’s 1996 standards, updated to incorporate the findings of educational leadership research conducted over the twelve-year period between the two editions. *ISLLC 2008* offered six policy standards intended to guide states and school divisions in the development of local standards for the training, licensure, and evaluation of school leaders. The authors asserted that “these standards represent the broad, high-priority themes that education leaders must address in order to promote the success of every student” (p. 6) and that increasing student achievement was the “ultimate goal” (p. 5) of the standards.

The six standards of *ISLLC 2008* addressed all aspects of educational leadership, including articulating and promoting a vision, promoting teaching and learning, organizing and managing operations, collaborating with faculty and the community, acting with integrity, and understanding the political and cultural context. Each standard includes a list of functions to “help define [the] strong school leadership” (CCSSO, 2008a, p. 6) needed to support the standard. *ISLLC Standard 2*, often referred to as the Teaching and Learning standard, is naturally the most relevant to the discussion at hand, and CCSSO (2008a) emphasized that Standard 2 comprises “the core work of education leaders” (p. 4).

\(^7\) ISLLC is an acronym for the Interstate School Leadership Licensure Consortium, a collaborative partnership between CCSSO and the National Policy Board on Educational Administration, which produced the 1996 Standards.
Standard 2 identifies a wide range of leadership functions, several of which are specific to the role of school principal, such as creating a motivating learning environment for students, supervising instruction, and maximizing time spent on quality instruction (CCSSO, 2008, p. 14). However, the responsibility for many of the functions identified in this standard is shared between school-level and district-level administrators, including nurturing a culture of collaboration, creating the curricular program, developing assessment systems, developing the instructional capacity of staff, and monitoring and evaluating the impact of the instructional program. Even in a small school, it would be virtually impossible for one leader to provide all of these functions consistently, especially in light of the fact that there are five other standards for educational leadership besides the Teaching and Learning standard, each with its own list of key functions. The breadth of these leadership functions that are essential to the promotion of effective teaching and learning makes it clear that educational leadership must extend beyond principals and superintendents to include supporting roles such as curriculum supervisors.

**Performance Expectations and Indicators for Educational Leadership**

CCSSO also published a companion document to *ISLLC 2008*, titled *Performance Expectations and Indicators for Educational Leaders* (hereafter referred to as *PEI 2008*). While *ISLLC 2008* was intended to guide policy decisions, *PEI 2008* was intended to “describe how leaders approach their work in ways that are observable and measurable” (CCSSO, 2008b, p. 7). In other words, *ISLLC 2008* described the “what” of educational leadership while *PEI 2008* described the “how.”

To translate ISLLC Standard 2 from policy to practice, *PEI 2008* offered a corresponding Performance Expectation 2 (PE2), asserting that educational leaders should “ensure achievement and success of all students by monitoring and continuously improving teaching and learning”
The authors noted the importance of providing coherent curriculum, materials, instruction, and assessment for meeting this expectation, and they identified three key elements of leadership that promote effective teaching and learning: A Strong Professional Culture; Rigorous Curriculum and Instruction; and Assessment and Accountability (CCSSO, 2008b, pp. 16-18). Each of these elements further identified specific performance indicators that illustrate what this expectation should look like in practice.

The performance indicators for PE2 describe a range of actions performed by both school-level and district-level leaders. This is similar to how the responsibility for the leadership functions supporting ISLLC Standard 2 were shared among school-level and district-level leaders. Specifically, the performance indicators for promoting a strong professional culture include guiding job-embedded professional development and providing ongoing, data-driven feedback to improve teaching and learning (CCSSO, 2008b, p. 17). In my personal experience, the sharing of responsibility for these indicators does not occur as a discrete divvying-up of the actions. Instead, the principals and I each provide professional development and feedback – not just to teachers, but to each other as well. Though teachers are typically the focus of my professional development and feedback efforts as mathematics supervisor, I also provide professional development and feedback for principals. Throughout this process, I learn from principals, receiving feedback that informs my work.

The performance indicators for developing rigorous curriculum and instruction focus on actions that are central to the role of the curriculum supervisor, including: developing a shared understanding of curriculum and instruction; aligning content standards, curriculum, teaching, assessment, and professional development; and monitoring the effects of the curriculum and instruction program (CCSSO, 2008b, p. 18). The performance indicators for promoting
assessment and accountability also include actions performed by curriculum supervisors, including: developing standards-based assessment incorporating multiple data sources to improve teaching and learning; guiding the regular analysis and disaggregation of data to improve teaching and learning; and monitoring and analyzing assessment data to provide accountability reporting and guide continuous improvement (CCSSO, 2008b, p. 18).

So far, this chapter has highlighted the impact of educational leadership on student achievement and established a view of educational leadership that includes administrative roles beyond those of principal and superintendent. Standards, performance expectations, and performance indicators for educational leadership have been reviewed to identify three important leadership functions of curriculum supervisors: developing and implementing curriculum, delivering professional development, and using assessment data to inform instruction and guide program evaluation. The following section confirms these leadership actions as central functions of the mathematics supervisor by examining recommendations specific to mathematics educational leadership.

**Mathematics Educational Leadership**

NCTM’s (2000) *Principles and Standards for School Mathematics* includes a Curriculum Principal, a Teaching Principle, and an Assessment Principle. These principles describe desirable characteristics of mathematics curriculum, instruction, and assessment that can guide the actions of mathematics educational leaders. The Curriculum Principle states that a mathematics curriculum should be “coherent, focused on important mathematics, and well articulated across the grades” (NCTM, 2000, p. 15) and should give teachers “guidance regarding important ideas or major themes” (p. 15). These recommendations speak directly to the need for mathematics educational leaders who develop and implement curriculum. The
Teaching Principle states that “teachers must know and understand deeply the mathematics they are teaching” (p. 17) and that they “must have frequent and ample opportunities and resources to enhance and refresh their knowledge” (p. 17), suggesting that mathematics educational leaders should provide professional development to enhance teachers’ content and pedagogical content knowledge. The Assessment Principle states that “assessment should support the learning of important mathematics and furnish useful information to both teachers and students” (p. 22). Mathematics educational leaders can support the use of assessment to improve teaching and learning by developing district-wide formative assessments, including performance-based assessments and benchmark tests. Assessment data can also be used to evaluate the success of the overall curricular program.

In 2008, the National Council of Supervisors of Mathematics (NCSM) published *The PRIME Leadership Framework: Principles and Indicators for Mathematics Education Leaders* (hereafter referred to as *PRIME 2008*) to “describe actions for mathematics education leaders across all settings, preK-12” (NCSM, 2008, p. 2). *PRIME 2008* established principles similar to those identified by NCTM, including principles for Curriculum Leadership, Teaching and Learning Leadership, and Assessment Leadership.

*PRIME 2008*’s Curriculum Leadership Principle states that mathematics education leaders should “ensure relevant and meaningful mathematics in every lesson” (NCSM, 2008, p. 33). The leadership actions for this principle include: developing and applying knowledge of state standards and national curriculum recommendations to guide local curriculum development; modeling the connections between the local curriculum, effective instruction, and student achievement; and providing ongoing review of curriculum alignment with state and national standards and assessments to promote continuous improvement (pp. 36-39). The
Teaching and Learning Leadership Principle states that mathematics education leaders should “ensure high expectations and access to meaningful mathematics instruction every day” (p. 21). A key indicator for this principle is that teachers participate in continuous professional development aimed at improving practice. Leadership actions for this principle include: developing and modeling knowledge about instructional strategies for improved student learning; facilitating growth of teachers’ mathematical knowledge and use of research-informed best practices; and facilitating participation in collaborative, site-based professional learning for every teacher (pp. 25-29). The Assessment Leadership Principle addresses the “timely, accurate monitoring of student learning and adjustment of teacher instruction for improved student learning” (p. 46) through the use of formative and summative assessments. Leadership actions for this principle include: assisting teachers in developing and using formative assessments; creating structures for collaborative analysis of formative assessment data to improve instruction; and facilitating the use of local, state, and national summative assessment data to evaluate and improve the mathematics curriculum.

These leadership principles presented by NCTM (2000) and NCSM (2008) are consistent with the curriculum supervisor leadership functions regarding curriculum, professional development, and assessment that were identified throughout the preceding sections of this chapter. These three leadership functions define the major work of the mathematics supervisor, and I will use them as the basis for the model of mathematics curricular leadership developed in the following section.

A Model for Mathematics Curricular Leadership

M. W. Brown (2009) noted that “curriculum materials have long played a central role in educational reform, with mixed results” (p. 17)). Cuban (1993) bluntly asserted that “this
popular strategy [of curriculum-based reform] has largely failed” (p. 182). On the surface, this finding seems somewhat surprising, since, as Ball and Cohen (1996) noted, “not only are curriculum materials well-positioned to influence individual teachers’ work but, unlike many other innovations, textbooks are already ‘scaled up’ and part of the routine of schools” (p. 6). However, Stein and Kim (2009) pointed out that “although it may be relatively easy to get curriculum materials to large numbers of teachers, it is much more difficult to assure that those materials are used and used well” (p. 37). An important reason for the failure of curriculum materials in promoting educational reform is the difference between the intended curriculum and the enacted curriculum (Ball & Cohen, 1996; Cuban, 1993; Lloyd et al., 2009), as discussed in Chapter 2. As Thompson and Senk (2010) explained, “how [the] textbook is implemented in a classroom (i.e., the implemented or enacted curriculum) is a significant determiner of what students are likely to learn” (p. 250). Ball and Cohen (1996) cited curriculum developers’ failure “to appreciate teachers’ need to learn in order to use new materials” (p. 6) as a key reason for the disparity between the intended and enacted curriculum. Remillard (2005) highlighted the interplay of these ideas in noting that:

The understanding that the process of using a mathematics curriculum guide is complex and dynamic and is mediated by teachers’ knowledge, beliefs, and dispositions suggests that the decision to adopt a single curriculum in a school or district will not alone result in uniform mathematics instruction. Teachers require substantial support in learning to use new materials. (p. 239)

The challenges of curriculum-based reform raise issues of curriculum development, curriculum implementation, and teacher professional development – which were identified as important functions of the mathematics supervisor in the preceding section. The remainder of this chapter
will present a model for mathematics curriculum leadership focusing on two leadership actions that can be provided by the mathematics supervisor to address these challenges: Curriculum Implementation and Supporting Curriculum Use.

**Reconsidering Curriculum Implementation.**

The first leadership action in my model for mathematics curriculum leadership is Curriculum Implementation, but it is important to note that I am applying a different meaning than the one traditionally given to this term. Oliva (2009) defined *curriculum implementation* as the “translation of plans into action” (p. 22). This description of implementation is typically used to refer to teachers’ interactions with curriculum materials to plan and deliver instruction, and teachers’ *fidelity of implementation* is often used as a measurement of curriculum implementation (e.g., National Research Council, 2004). Snyder, Bolin, and Zumwalt (1992) stated that this type of fidelity approach includes “(1) measuring the degree to which a particular innovation is implemented as planned and (2) identifying the factors which facilitate or hinder implementation as planned” (as quoted in McClain et al., 2009, p. 56). However, Brown, Pitvorec, Ditto, and Kelso (2009) noted that “the level of fidelity to the written curriculum differs from the level of fidelity to the authors’ intended curriculum during lesson enactments” (p. 363), and Remillard (2005) questioned whether “it is possible to realize a precise match between the curriculum as written and as enacted in the classroom” (p. 239). In light of these concerns, several researchers have recently called for a “re-conceptualization” (Larson, 2009) of the notion of fidelity of implementation (S. A. Brown et al., 2009; Chval, Chavez, Reys, & Tarr, 2009; McClain et al., 2009; Remillard et al., 2009).

Chapter 2 of this dissertation supported the re-conceptualization of fidelity by establishing a view of teaching as a design activity and by characterizing curriculum materials as
tools and teachers as decision makers who offload, adapt, and improvise with those tools. I distinguished between the terms use and implementation, selecting use to describe teachers’ interactions with curriculum materials (Lloyd et al., 2009) because it emphasizes the role of teachers as decision makers and parallels the concept of curriculum as a continuously evolving plan for action. These ideas reinforce a new definition of fidelity of implementation as the “use of the text as a tool that results in student learning consistent with the district’s learning goals for students” (Larson, 2009, p. 97).

I recommend taking this idea one step further and reconsidering the notion of curriculum implementation as well. Oliva (2009) described curriculum implementation as putting plans into action, referring to teachers’ work at the classroom level. In light of the preceding discussion of fidelity of implementation and teachers’ use of curriculum materials, I believe that this term is more appropriate for describing the curricular leadership actions of bringing the curriculum into existence, including development, planning, dissemination of materials, and evaluation. Oliva (2009) included these actions under the umbrella term curriculum development, but I prefer using curriculum implementation instead, based on the meaning of the verb implement as “to give practical effect to” (Merriam-Webster Online Dictionary, 2010). For the remainder of this dissertation, I will define Curriculum Implementation as the systemic leadership actions that establish and promote a district-wide curriculum.

Curriculum Implementation may be carried out by different levels of educational leaders, including superintendents and principals, and I would argue that it represents a primary function of the mathematics supervisor. Table 1 provides examples of the curriculum implementation actions performed by these three mathematics educational leaders.
Table 1

Educational Leadership Actions Promoting Curriculum Implementation

<table>
<thead>
<tr>
<th>Role</th>
<th>Action</th>
</tr>
</thead>
</table>
| Superintendent   | • Establish district-wide policies for curriculum development and textbook adoption.  
|                  | • Establish expectations for principals regarding curriculum implementation. |
| Mathematics      | • Supervise textbook adoption.                                           |
| Supervisor       | • Organize teacher teams to assist with development of curriculum documents, pacing guides, and benchmark assessments.  
|                  | • Disseminate curriculum materials.                                     |
| Principal        | • Ensure that all teachers and students have access to curriculum materials.  
|                  | • Establish expectations for teacher use of curriculum materials.        |

Supporting Curriculum Use.

In addition to promoting curriculum implementation, I suggest that there is another important aspect of mathematics curricular leadership that is particularly relevant to the work of the mathematics supervisor: supporting teachers’ use of curriculum materials. Once teaching is understood to be a design activity, it follows that educational leadership should support teachers in learning to use curriculum materials flexibly to design effective instruction. M. W. Brown (2009) suggested that “it may be possible to design materials and professional development in ways that facilitate different types of productive curriculum use by teachers” (p. 31). Supporting teachers by developing curriculum materials and delivering professional development are two of the central functions of the mathematics supervisor previously identified in this chapter.

Figure 10 presents my model for mathematics curricular leadership, relating the actions of Curriculum Implementation, Supporting Curriculum Use, and Curriculum Use and providing

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8 It should be noted that this conception of curriculum implementation focuses only on educational leadership; it is not intended to address teachers’ use of curriculum materials, and it is not related to the traditional concept of teachers’ fidelity of curriculum implementation.
examples of the educators who perform these actions. The left-hand section of the model indicates that the curriculum leadership functions of superintendents, directors of instruction, and principals are typically limited to the level of curriculum implementation, while the right-hand section indicates that teachers are the primary users of curriculum. The center section of the model indicates that many mathematics educational leaders provide both types of curricular leadership, including curriculum supervisors, instructional specialists/coaches, department chairs, and grade-level team leaders. Note that the curriculum supervisor is the only district-level leader included under Curriculum Implementation and Supporting Curriculum Use, highlighting the unique position of the mathematics supervisor as a curricular leader.

This model for mathematics curricular leadership demonstrates that, as Mathematics Supervisor for my school district, I was well-positioned to conduct a study of the development of CSM intended to support teaching as design, because the goal of these resources was directly aligned with the leadership action of Supporting Curriculum Use. The model informed the development of the CSM (see Chapter 5) as well as the structure of the study (see Chapter 6), and guided me in my role as a practitioner-researcher.
Summary

This chapter began by highlighting the impact of educational leadership on student achievement, noting that it is second only to classroom instruction in terms of importance among school-related factors (Leithwood, Louis, Anderson, & Wahlstrom, 2004). A view of educational leadership was then established that includes administrative roles beyond those of principal and superintendent. Standards, performance expectations, and performance indicators for educational leadership were outlined, and three central leadership functions of the mathematics supervisor were identified: developing and implementing curriculum; delivering professional development; and using assessment data to inform instruction and guide program evaluation. A case was then made for re-conceptualizing the notions of fidelity and curriculum implementation, based on a leadership model focused on Curriculum Implementation and Supporting Curriculum Use as two important leadership actions of the mathematics supervisor.
Chapter 4: Understanding Design Research

The preceding chapters explained teaching as design and described the role of the mathematics supervisor – the “what” and the “who” of the study; this chapter addresses the “how.” It provides a literature review describing the origins, rationale, and underlying principles of design research, outlines a process for conducting design research, and addresses the challenges associated with this research method, setting the stage for the descriptions of the development of the CSM (Chapter 5) and the structure of the study (Chapter 6) that will follow.

Educational design research, as its name implies, refers to the application of design research methods to the study of topics in education such as teaching, learning, technology, and curriculum. Van den Akker, Gravemeijer, McKenney, and Nieveen (2006a) used the term design research to describe “a family of related research approaches…. including (but not limited to): Design studies, Design experiments, Development/Developmental research, Formative research, Formative evaluation, [and] Engineering research” (p. 4); this convention is followed throughout this dissertation.

Origins, Rationale, and Principles

Over the past two decades, there has been strong debate among policy makers and academics regarding the quality, value, and goals of education research, fueled by the increasing demand for evidence-based policy and practice to promote school reform (Biesta, 2007, pp. 1-5; Feuer et al., 2002; Tooley & Darby, 1998). In a lecture at the London Teacher Training Agency, David Hargreaves (1996) criticized the field of education research for failing to generate an agreed-upon knowledge base for teachers, for being non-cumulative and rarely replicated, and for being conducted primarily by non-practitioners. Hargreaves’ commentary is generally representative of a call for the increased use of scientifically-based methods in education.
research (particularly the use of experimental designs with random assignment) based on unfavorable comparisons between educational and medical research (Raudenbush, 2002; Slavin, 2002).

While the debate over the role of scientifically-based research in education is far from settled (Coessens & Van Bendegem, 2006; Cooper, Levin, & Campbell, 2009; Erickson & Gutierrez, 2002; Simons, 2003), a key issue that has emerged from the discussion is how to form better connections between scholarship and practice. The persistent perception of a gap between education research and classroom practice is a primary reason behind the lack of support for education research among policy makers and practitioners (Kaestle, 1993; Shavelson & Towne, 2002, p. 14). Lagemann (1999) noted that:

Although there are abundant examples of current and past research-based innovations in classrooms, these have often been short-lived, or their precise research lineage has not been known to the teachers involved. Instances of effective linkages between research and practice have therefore gone unnoticed. (p. 3)

Hargreaves (1996) further lamented that “trainee teachers soon spot the yawning gap between theory and practice and the low value of research as a guide to the solution of practical problems” (p. 2). Since improvement of practice is presumably a reasonable measure of the value of education research, there is a clear need to develop better connections between research and practice and to disseminate those connections in order to expand their impact on practice and inform future research. Several authors have proposed that a way to address this problem is to include practitioners in setting education research agendas and conducting research, as well as in reporting and implementing the findings (Bulterman-Bos, 2008; Kaestle, 1993; Simons, Kushner, Jones, & James, 2003; Tooley & Darby, 1998). Design research is a methodology
based on collaboration between researchers and practitioners that is well-suited to address the disconnect between research and practice (Vanderlinde & van Braak, 2010).

Concurrent with the debate surrounding education research, design research has been steadily evolving from the initial work of A. L. Brown (1992) and Collins (1992). The growth of design research in education has been demonstrated by special issues of the journals *Educational Researcher* (32(1), 2003) and *Journal of the Learning Sciences* (13(1), 2004) devoted to discussion and analysis of the methodology. More recently, van den Akker et al. (2006b) attempted to clarify the characteristics of design research while outlining standards of quality that can be used to evaluate the outcomes of this approach.

Not surprisingly, there is no clear-cut definition of design research. Van den Akker et al. (2006a) adopted a “generic” definition, originally offered by Barab and Squire (2004), describing design research as “a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings” (p. 2). This definition highlights three of the key principles of design research that have the potential for connecting research to practice: context, use, and theory.

Design research is intended to study teaching and learning in context (Collins et al., 2004), in the “messy situations that characterize real-life settings” (Collins, 1999, p. 291). Real-world teaching and learning occur in complex social situations, so conclusions based solely on the outcomes of laboratory research may not translate directly to the classroom (Barab & Squire, 2004; A. L. Brown, 1992; Collins, 1999). Design research aims to provide better understanding of educational interventions by studying their implementation in the real world. Van den Akker et al. (2006a) argued that, in part because it is conducted in naturalistic settings, design research “can contribute to more practical relevance” (p. 4), and Collins (1999) noted that such studies of
real-world learning environments are “propelled by the desire to bridge the gap between research and practice” (p. 289).

However, instead of simply describing interventions in context and evaluating their effectiveness, design research involves actively refining interventions through a cycle of design, evaluation, and revision (van den Akker et al., 2006a) in order to maximize their impact. Since it is primarily concerned with use, design research is a form of applied education research (Fraenkel & Wallen, 2009, p. 7) that addresses Hargreaves’ desire for education research to align more closely with applied medical research “that gathers evidence about what works in what circumstances” (1996, p. 2). Further, by “carry[ing] experimentation into real-life settings in order to find out what works in practice” (Collins, 1999, p. 290), design research attempts to provide practitioners with those “solutions to practical problems” called for by Hargreaves (1996, p. 2).

A third key principle of design research is the desire to produce and refine theories of teaching and learning that are directly informed by practice (Barab & Squire, 2004; Reeves, 2006; van den Akker, 1999; van den Akker et al., 2006a). The Design-Based Research Collective (2003) identified this emphasis on theory as a defining characteristic of design research, noting that “research on designs must lead to sharable theories that help communicate relevant implications to practitioners and other educational designers” (p. 5). This focus on generalizing beyond the original intervention distinguishes design research from formative evaluation (Barab & Squire, 2004), since the results of formative evaluation are typically intended only for local use (Russ-Eft & Preskill, 2009, pp. 18-19), and can be traced back to A. L. Brown’s initial work: “I attempt to engineer interventions that not only work… but are also based on theoretical descriptions that delineate why they work, and thus render them reliable and
repeatable” (A. L. Brown, 1992, p. 143). Shavelson and Towne (2002, pp. 120-123) highlighted this combination of theory-driven design and data-driven refinement as a key aspect of design research that makes it a promising methodology. By generating and refining theory based on empirical evidence of effective practice, design research has the potential to overcome teachers’ skepticism of the value of education research (Vanderlinde & van Braak, 2010).

In addition to its focus on context, use, and theory, design research has the potential to connect research to practice because it involves direct collaboration with practitioners throughout the research process. In his foundational article on design research in education, Collins (1992) was explicit about the need to include teachers as co-investigators:

…it is absolutely critical that teachers take on the role of co-investigators helping to formulate the questions to be addressed and the designs to be tested, making refinements in the designs as the experiment progresses, evaluating the effects of the different aspects of the experiment, and reporting the results of the experiment to other teachers and researchers. (p. 17)

A. L. Brown described her collaborative interactions with teachers during the implementation of a design as follows: “I’m not telling the teacher… what I want done… I watch her implement it, and I watch her change it. Actually, I’m totally dependent on a gifted teacher” (as quoted in Kaestle, 1993, p. 26). Bulterman-Bos (2008) recommended the development of a clinical research practice in education to create an “overlapping role of the researcher and the professional” (p. 418). She stated that “because of the overlap, researchers are automatically inclined to tailor their work to what serves the needs of the professional practice” (p. 418), noting that design research would be a natural component of such a clinical practice. The collaboration between researchers and practitioners inherent in design research is in line with the
recommendations for improving education research previously noted in this section (e.g., Hargreaves, 1996; Kaestle, 1993).

It is important to note that comparisons of design research to traditional psychological research do not represent an “either or” proposition (McCandliss, Kalchman, & Bryant, 2003). A. L. Brown (1992) clearly stated her belief that laboratory research can inform design research and vice versa: “I find that switching back and forth from both types of research settings enriches my understanding of a particular phenomenon” (p. 152). Shavelson and Towne (2002) noted the importance of employing research methods that permit direct investigation of research questions, citing the need for multiple research approaches to the same question:

Particular research designs and methods are suited for specific kinds of investigations and questions, but can rarely illuminate all the questions and issues in a line of inquiry.

Therefore, very different methodological approaches must often be used in various parts of a series of related studies. (p. 4)

Likewise, Erickson and Gutierrez (2002) suggested that, because of the wide variation that occurs across implementations of educational treatments, it is necessary to document thoroughly the characteristics of a given implementation using qualitative methods in order to validate any causal inferences drawn from experimental data. This idea speaks directly to the complementary natures of design research and psychological research.

**Process**

Just as there is no clear-cut definition of design research, there is also no prescribed set of steps to follow in conducting this type of research. Instead, design researchers tailor their studies to the particular demands of the research questions, interventions, and settings under consideration. While this provides researchers with the flexibility to study a wide range of
questions, this freedom must be balanced with a commitment to the design research principles of collaboration, context, use, and theory if this method is to produce useful findings. This section outlines a model that can be used to guide the design research process, identifies important features of the process, and highlights significant differences between design research and traditional psychological research.

In his assessment of the effectiveness of educational technology research, Reeves (2006) reached a familiar conclusion: research into educational technology has been just as ineffective as the broader field of education research in terms of improving teaching and learning. He argued that design research, for many of the reasons already noted, is particularly well-suited to the study of educational technology, and offered a model comparing design research to predictive research, shown in Figure 11.

**Figure 11.** Reeves’ comparison of predictive and design research (Reeves, 2006, p. 59). Used under fair use guidelines, 2011.
Although Reeves presented this model in the context of educational technology research, it serves as a useful outline for educational design research in general, emphasizing that design research is a cyclical process (Design-Based Research Collective, 2003; van den Akker et al., 2006a) based on practical application.

Reeves’ model highlights four phases of the design research cycle: Analysis, Development, Testing and Refinement, and Reflection. These phases encompass the four key design research principles of collaboration, context, use, and theory discussed in the previous section. In Figure 12, I have highlighted the connections between Reeves’ phases and these principles of design research. These connections are elaborated upon in the following description of the phases.

**Figure 12.** Reeve’s model of design research, modified to highlight its connections to the design research principles of collaboration, context, use, and theory. Used under fair use guidelines, 2011.

During the Analysis phase, researchers work closely with practitioners to define the research problem. That this initial collaboration is an essential component of the process is supported by Collins’ (1992) assertion that “[design] experiments must work within the
constraints that the teachers involved think are necessary to be successful, and at the same time must address questions that the teachers would like answered” (p. 17). Herrington (2010, March) also noted that practitioners can provide insight into the research problem during this phase, resulting in better articulation of the problem.

The Development phase focuses on the design of an intervention to address the research problem. In this phase, researchers “interrogate the literature” in search of existing theory to inform the design (Herrington, 2010, March). The goal is to create an initial design that is grounded in theory and has promise for successfully addressing the research problem. Shavelson and Towne (2002, pp. 120-123) stressed this connection between theory and design as vital to establishing design research as a “scientific” research method.

Once the design is complete, the intervention is implemented, evaluated, and adjusted in cycles throughout the Testing and Refinement phase, with each iteration of the intervention “play[ing] a role similar to systematic variation in experiment” (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003, p. 9). This phase is essentially a series of formative evaluations of the successive design revisions to determine how well the intervention is working and to guide its continuous improvement. The focus is on understanding how and why the intervention works and not simply to prove that it works (Herrington, 2010, March). Collins (2004) noted that this process is similar to the model of progressive refinement originally developed by Japanese automobile manufacturers: “By studying a design in practice with an eye toward progressive refinement, it is possible to develop more robust designs over time” (2004, p. 19). The Testing and Refinement phase underscores design research’s focus on practical use.

The Reflection phase brings the researchers and practitioners together to analyze the effects of the intervention and generate “design principles to enhance both practical and
theoretical understanding of the problem area” (Herrington, 2010, March, Slide 21). Reeves (2006) noted the benefit of collaboration between researchers and practitioners during the Reflection phase in developing “robust design models and principles” (p. 59), and it is this goal of developing theory and practice simultaneously that extends design research from formative evaluation to scientific research (Barab & Squire, 2004).

Although Reeves’ model captures the most salient features of design research, van den Akker et al. (2006a) suggested that design research may be better understood by also examining “what it is not” (p. 5). To that end, the remainder of this section will address significant differences between design research and traditional psychological research.

Collins et al. (2003) identified seven such differences:

1) messy situations versus laboratory settings;
2) multiple dependent variables versus a single dependent variable;
3) characterizing the situation versus controlling variables;
4) flexible design revision versus fixed procedures;
5) social interaction versus social isolation of participants;
6) developing a profile versus testing hypotheses; and
7) co-participant versus experimenter design and analysis. (pp. 20-21; see also Collins, 1999, pp. 290-293)

Four of these differences are directly related to the concepts of collaboration, context, and progressive refinement discussed previously, but the three remaining differences warrant further consideration: multiple dependent variables versus a single dependent variable, characterizing the situation versus controlling variables, and developing a profile versus testing hypotheses.
Van den Akker et al. (2006a) asserted that “the most noteworthy aspect [of design research] is probably that design researchers do not emphasize isolated variables” (p. 5). While laboratory research typically focuses on measuring a treatment’s effect on a single dependent variable, design research focuses instead on understanding multiple dependent variables, treating the intervention as an integrated system (A. L. Brown, 1992; van den Akker et al., 2006a). This interest in the multiple outcomes of systems stems from the contextual nature of design research (Collins et al., 2004; van den Akker et al., 2006a). As Kelly (2006) noted, “design research does not strive for context-free claims; rather, it sees context as central to its conceptual terrain. …It thus does not seek to randomize away…‘nuisance variables’, but to engage, understand and influence them…” (p. 113).

Dependent variables of interest to design researchers can be classified into three types: climate variables (e.g., student engagement, cooperation, and risk-taking), outcome variables (e.g., learning of content or strategies), and system variables (e.g., dissemination, ease of use, and sustainability) (Barab & Squire, 2004; Collins, 1999; Collins et al., 2004). Naturally, evaluating multiple dependent variables requires the use of multiple assessments (A. L. Brown, 1992; Collins, 1992) suitable for measuring different types of variables. For example, Collins (1999) recommended the use of observations, interviews and surveys to study climate variables, while suggesting that outcome variables are better measured through pre- and posttests or evaluations of products.

A second important difference between design research and traditional psychological research is closely related to the issue of multiple dependent variables: characterizing the situation versus controlling variables. In traditional psychological research, researchers explicitly attempt to control extraneous variables in hopes of preserving internal validity.
In design research, however, “there is no attempt to hold variables constant; instead the goal is to identify all the variables, or characteristics of the situation, that affect any dependent variables of interest” (Collins, 1999, p. 291). Similar to its focus on multiple dependent variables, this aspect of design research is also a logical consequence of the contextual nature of the method; since understanding how and why interventions work in the real world is a primary goal of design research, holding potentially confounding variables constant could “undermine the usefulness of the results” (Collins, 1999, p. 291). As A. L. Brown (1992) noted, shifting from laboratory settings to real-world contexts “involves an increasing trade-off between experimental control and richness and reality” (p. 152). Design researchers attempt to capture that richness and reality by providing detailed characterizations of the situations being studied.

The final issue that will be discussed in this section is the difference between the design research goal of developing a profile and the traditional psychological research goal of testing hypotheses. In experimental psychological research, researchers generate hypotheses that are tested through systematic variation of the learning conditions in an attempt to identify causal relationships (Fraenkel & Wallen, 2009, p. 262). In contrast, design research aims to generate a descriptive profile of an intervention that identifies its essential features, including the structure of the design, the setting, descriptions of each phase, and the outcomes (A. L. Brown, 1992; Collins et al., 2004). Collins (1999) compared this type of profile to a product evaluation conducted by Consumer Reports: “The goal is to look at many different aspects of the design and develop a qualitative and quantitative profile that characterizes the design in practice” (p. 292). A. L. Brown (1992) suggested a similar approach, noting that she preferred to “mix and match qualitative and quantitative methodologies in order to describe the phenomena” (p. 156).
Detailed reporting of all aspects of a design research study can facilitate generalization and transfer of the research findings (Design-Based Research Collective, 2003; van den Akker, 1999). As Collins et al. (2004) noted, “a detailed design history… allows research audiences to evaluate the credibility of design decisions, and the quality of lessons learned from the research” (p. 34). These differing goals make design research and experimental psychological research complementary methods that have the potential to provide corroborating evidence about teaching and learning.

Discussion of the differences between design research and traditional psychological research naturally leads to discussion of the challenges inherent in conducting design research, because these differences form the basis of questions about the knowledge claims produced through design research studies.

**Addressing the Challenges of Design Research**

The fundamental issue confronting design research is essentially the same one confronting all scientific research: Are the resultant knowledge claims trustworthy? (Barab & Squire, 2004; Collins et al., 2004; Shavelson et al., 2003). Several of the characteristics typical of design research studies have led to reasonable concerns about its ability to produce generalizable findings, including the lack of control groups, small sample sizes, context-dependency, and reliance on narrative accounts as primary sources of data (Shavelson et al., 2003; Sloane & Gorard, 2003). Shavelson (2003) summed up this issue nicely:

> Should we believe the results of design experiments? A group working in the design study mode might eventually produce an impressive concrete product (a curriculum or instructional unit, for example), but the issue remains – does this practical success
warrant whatever knowledge claims the group makes when it reaches the end of the complex (and often tortuous) design path? (p. 25)

In response to this question of credibility, the design research community has worked to establish “standards that improve the quality of this approach” (van den Akker et al., 2006a, p. 3). The special journal issues (Educational Researcher 32(1), 2003; Journal of the Learning Sciences 13(1), 2004) mentioned previously were focused on delineating the characteristics of design research and justifying its merits in relation to other research methods, and several authors have suggested criteria for evaluating the quality of design research studies (Edelson, 2006; Kelly, 2006; Phillips, 2006). Interestingly, however, these attempts at establishing standards of quality have resulted in few specific recommendations highlighting a clear path toward improving the trustworthiness of design research findings. In fact, Kelly (2006) noted that:

While I am able to say that good design research requires plans for research-driven design, systematic documentation, formative evaluation, and generalization, I must acknowledge that we lack accepted methods for developing and executing these plans.

Each design research effort must essentially invent these methods itself. (p. 105)

This statement reflects the double-edged nature of design research: Its flexibility gives researchers the power to study virtually any learning situation, but a lack of agreed-upon standards leaves its results subject to question. Further, the wide range of possible interventions, contexts, and goals of design research studies makes it difficult to establish such standards, especially since the design research community lacks a centralized infrastructure to facilitate communication and organization (Collins et al., 2004). Given that the existing literature is far from definitive in regard to resolving this issue, simply listing the myriad suggestions for
improving the credibility of design research would not be particularly helpful. Instead, I offer a synthesis of a few existing recommendations that may provide an effective way forward.

To restate the problem: The flexibility of the design-implement-assess-refine cycle provides a significant advantage in terms of connecting research to practice while simultaneously creating barriers to generalizability. Any proposed solution must address both sides of the problem, preserving flexibility while increasing credibility.

Revisiting Reeves’ four phases of the design research process, the middle phases of Development and Testing and Refinement comprise the essence of design research’s flexibility. Attempts to standardize the work of design researchers during these phases would be likely to result in detrimental decreases in this flexibility. Consequently, establishing standards of quality for the Analysis and Reflection phases would seem to be a more promising approach.

In the Analysis phase, articulating standard types of design research questions could provide a level of consistency across design research studies, making them easier to compare and evaluate. In the Reflection phase, establishing standards for the reporting of findings could allow studies to be evaluated more easily to assess the reasonableness of their conclusions and make it easier to replicate studies in other settings. Together, the setting of standards in the Analysis and Reflection phases offers a possible solution to the problem of design research’s credibility. In Figure 13, I have adapted Reeves’ model to illustrate this point.
The remainder of this section will elaborate my rationale for establishing design research standards in the Analysis and Reflection phases.

It has already been noted that Shavelson and Towne (Shavelson & Towne, 2002) recommended the application of multiple research methods in a series of related studies to understand a given phenomenon. They stated that “methods can only be judged in terms of their appropriateness and effectiveness in addressing a particular research question” (p. 3). Along these lines, Shavelson et al. (2003) indicated that design research is well-suited to answering three generic types of questions: (a) *What is happening?*, (b) *Is there a systematic effect?*, and (c) *Why or how is it happening?* (p. 28). They noted that the type of research question suggests the appropriate data collection methods that may be used within the larger design research study. For example, the question, “What is happening?” might best be answered by a combination of
ethnographic and case study methods, while the question, “Is there a systematic effect?” might require an experimental or quasi-experimental approach. The authors posited that applying design research to these types of research questions, matching appropriate methods to appropriate questions, would promote scientific rigor and thereby increase the credibility of the findings (Shavelson et al., 2003, p. 28). Establishing agreed-upon research questions for which design research would provide a standard to guide researchers during the Analysis phase. It should be noted that Susan McKenney expressed concern over such a limiting of the range of research questions, asserting that design research is a robust method capable of addressing a broad range of research questions (personal communication, March 26, 2010). Feuer et al. (2002), however, asserted that: “The question drives the method, not the other way around. The overzealous adherence to the use of any given research design flies in the face of this fundamental principle” (p. 8).

At the other end of the design research process, “it is extremely important for the design experimenter to consider dissemination issues” (A. L. Brown, 1992, p. 171), especially in terms of the future testing, validation, and scaling of successful interventions. Barab and Squire (2004) noted that “this involves not simply sharing the designed artifact, but providing rich descriptions of context, guiding and emerging theory, design features of the intervention, and the impact of these features on participation and learning” (p. 8). However, just as there is “no commonly agreed-on format” (Fraenkel & Wallen, 2009, p. 627) for reporting the findings of qualitative research in general, the content of reports of design research studies can vary widely from study to study. Inconsistent methods of reporting findings can impede the design research community’s ability to address questions of quality, including those raised by Barab and Squire (2004):
What counts as reasonable and useful warrants for advancing assertions investigated through this type of research? …How do we control researcher bias in selecting evidence, in reporting observations, and in developing trustworthy claims? How do we understand the contextuality of research claims generated in situ and use them to inform broader practice? (p. 3)

Establishing standards for the reporting of findings during the Reflection phase could provide the means to address these questions by facilitating the evaluation, comparison, and replication of design research studies.

Collins et al. (2004) proposed a five-part structure for reporting design research findings, arguing that “because design research reconceives the experimental process, there needs to evolve a different structure for reporting” (p. 38):

1. Goals and elements of the design: “Goals, critical elements, and their interactions need to be described in enough detail, so that it is possible to evaluate how well the design was implemented in different settings” (p. 38).

2. Settings where implemented: “Differences between how the design was implemented in each setting should be detailed, so that readers can evaluate how faithfully the design was carried out in each setting” (p. 38).

3. Descriptions of each phase: Should include descriptions of each phase and the rationale for each design revision.

4. Outcomes found: “…a profile of values on the dependent variables… much like qualitative and quantitative data are reported about different products in Consumer Reports” (p. 39).
5. Lessons learned: “…a coherent picture of how the design evolved…” (p. 39), including descriptions of the limitations and successes.

Although this framework does not specifically address every concern about the credibility of design research findings, it provides a useful starting point, because each step facilitates the evaluation of the findings by other researchers and practitioners. In particular, the first and fourth steps allow for critical examination of the theoretical grounding of the design and the measurement of its impact, making it easier to evaluate the resultant knowledge claims.

By preserving the flexibility of the Development and Testing and Refinement phases while establishing standards for the Analysis and Reflection phases, this adaptation of Reeves’ model has the potential for improving the trustworthiness of design research findings.

Summary

Educational design research is a flexible methodology that can be applied to a wide range of research questions. Key aspects of design research include its focus on context, use, theory, and collaboration with practitioners. This method can be used to complement traditional psychological methods to provide a more thorough understanding of research questions in education. Reeves’ four phases of Analysis, Design, Testing and Refinement, and Reflection provide a useful starting point for organizing the design research process, and I have proposed an adaptation of this model aimed at promoting standardization to increase the trustworthiness and transferability of the findings of design research studies through the use of consistent question design and reporting of findings.

As a final thought on the nature of design research, it should be remembered that this is an evolving methodology with seemingly great potential for connecting educational research to practice – and its potential likely outweighs the method’s risks (Edelson, 2006). As Dede (2004)
pointed out: “The process of [design research] is itself a design, and its evolution should proceed using the same design and research methodologies we apply to the innovations this method generates” (p. 105).

**Implications for the Study**

As presented in Chapter 1, this study was well-suited for a design research approach because of the exploratory nature of the study, the nature of the research questions, the nature of the CSM, and the study’s alignment with the four key principles of design research presented in this chapter. Guided by Reeves’ model of the phases of design research, I conducted a modified cycle of Analysis, Development, Testing, and Initial Reflection to fit within the time constraints of my professional and academic schedule. Adhering to the recommendations for improving the credibility of design research made in this chapter, this dissertation employs the reporting structure suggested by Collins et al. (2004):

1. The goals and elements of the CSM are discussed throughout Chapters 1, 2, 5, and 6.
2. The context of the study, including the characteristics of the research team, is described in Chapter 6: Structure of the Study.
3. Descriptions of the phases are included in Chapter 2 (Analysis), Chapter 5 (Development), Chapter 6 (Testing), and Chapter 7 (Initial Reflection).
4. The outcomes of the study are discussed in Chapter 7: (Initial Reflection).
5. Lessons learned are included in Chapter 8: Conclusions.
Chapter 5: Design of the Curriculum Support Materials

This chapter describes the Development phase of the study. It outlines the design process, including the rationale behind the design decisions, and provides a detailed description of the final product – the CSM web site that was introduced during the discussion of the Analysis phase in Chapter 2.

The focus of this study was the design, development, and pilot testing of Curriculum Support Materials (CSM) intended to promote elementary mathematics teachers’ understanding of teaching as design and to support them in beginning to engage in teaching as design. As discussed in Chapter 2, the Design Group (DG) opted to deliver the CSM through a web site. This decision was based on the findings of the spring 2010 needs assessment (see Chapter 1) indicating that our teachers preferred online curriculum resources, as well as my desire to link the CSM to the district’s existing online resources in the future. This chapter describes our process for creating the CSM web site over the course of the Development phase of the study and details each section of the site (complete screen captures of the web site are included in Appendix D). I begin with a brief discussion of the research base that guided our work during this phase.

Curriculum Support Materials

Characterizing teaching as a design activity has implications for the design of curriculum materials and professional development. Larson (2009) stated that “we need to consider materials that support different modes of use by diverse teachers over time. The materials need to be robust enough to accommodate offloading, adapting, and improvising” (p. 97). In terms of professional development, M. W. Brown (2009) argued that “in addition to receiving support in learning subject matter and ways of teaching the content, which many have long advocated,
teachers also require support in exploring which resources to use and how to use them” (p. 33). This section will outline several recommendations for the design of curriculum materials and professional development to support their use.

M. W. Brown (2009) identified three principles to consider when creating curriculum materials to promote teaching as design: providing multiple points of access; employing a resource-centric design; and creating reusable resources and supporting customization (p. 32). Providing multiple points of access to resources accommodates their use by teachers with varying levels of experience and expertise. This could be accomplished by providing a database of resources that allows skilled teachers to browse and assemble resources to develop their own lessons, but that also includes “pre-authored materials that have been annotated by designers with pedagogical affordances describing how they might be used” (p. 32). In essence, this principle amounts to differentiating curriculum materials for teachers in the same way that teachers differentiate instructional materials for students.

Employing “a resource-centric approach to the design of curriculum materials” (M. W. Brown, 2009, p. 32) means creating resources that can function as building blocks for lessons, as opposed to offering resources that are overly scripted. A key element of this principle is that the purposes behind the resources are made “transparent” (Davis & Krajcik, 2005) to the teachers. Promotion of transparency was supported by Stein and Kim (2009), who argued that curriculum materials that “arm teachers with an understanding of the mathematical significance of the tasks that appear within them, as well as ideas about how students might respond to those tasks, are more likely to lead to successful enactments in the classroom” (p. 44).

M. W. Brown’s third design principle, creating reusable resources and supporting customization, is fairly self-explanatory; however it may be the most difficult to realize. He
noted that, “for an instructional unit to be both adaptable and meaningful, it needs to organize instructional resources and activities according to a clear rationale, but not be so structured as to require any single mode of use” (M. W. Brown, 2009, p. 33). He suggested including annotations that describe alternative uses for the resources as one way to support reusability and customization.

Ball and Cohen (1996) also identified several goals for the design of curriculum materials that would “make central the work of curriculum implementation [i.e., use]” (p. 7), noting that curriculum materials could:

…help teachers learn to listen to and interpret what students say, and to anticipate what learners may think about or do in response to instructional activities… support teachers’ learning of content… [so that] teachers might be better oriented to the possibilities of the materials, and better able to hear their students’ ideas… [and] help teachers to consider ways to relate units during the year. (Ball & Cohen, 1996, p. 7)

Together with M. W. Brown’s (2009) three principles, these suggestions highlight important considerations for the design of curriculum materials, all of which emphasize teacher use. As Remillard (2005) noted, “the designers of curriculum materials… must carefully consider how they frame and support the teacher-curriculum relationship” (p. 240).

M. W. Brown (2009) also offered a recommendation for professional development to support teaching as design, asserting that it “should help teachers link their instructional goals to the specific features and affordances of curriculum materials and support teachers in making the necessary design modifications required to achieve this alignment” (p. 33). He argued that such professional development would support teachers’ “skills in crafting instruction” while promoting professional dialogue about teaching and learning. In other words, curriculum
materials must be accompanied by professional development regarding their use if they are to support teaching as design. Ball and Cohen (1996) summed up this idea nicely when they proposed that "teachers could be engaged with curriculum materials in ways that generated learning if the materials were integrated into a program of professional development aimed at improving their capacity to teach" (p. 8). The CSM web site was intended to promote teaching as design by providing curriculum resources and professional development aligned with the recommendations discussed in this section.

**Designing the CSM Web Site**

I collaborated with the DG through three face-to-face meetings, as well as numerous emails and informal conversations, to create the CSM web site during the seven-week Development phase of the study. The site was designed to reflect the study’s research questions: Part of the site was intended to help teachers understand teaching as design, and part of the site was intended to support teachers in beginning to engage in teaching as design. The sections explaining teaching as design focused on the five essential features identified in Chapter 2:

1) Planning backward from learning goals.
2) Selecting assessments before lessons.
3) Reviewing available resources.
4) Matching instruction to goals and assessments.
5) Using ongoing formative assessment to guide instruction.

The sections intended to support teachers in engaging in teaching as design were organized around a single mathematics topic: Introducing Multiplication and Division. This topic was selected by the members of the Implementation Group (IG) during the first research team meeting, because they felt it included important concepts with which many second graders
typically struggle, and because the timing of a pilot unit on this topic would align with the pacing of the district’s second grade curriculum. In addition, the DG believed that, since teaching as design can be employed with any topic (Wiggins & McTighe, 2005), choosing one that could be pilot tested with minimum disruption to the IG teachers’ regular practices was more important than the topic itself, making Introducing Multiplication and Division an appropriate choice. The DG’s selection of the mathematics content related to this topic was informed by NCTM’s *Principles and Standards for School Mathematics* (2000) and *Curriculum Focal Points* (2006), CCSSO’s *Common Core Standards for Mathematics* (2010), and the Virginia Standards of Learning for Mathematics (2009). These sections of the web site included resources intended to develop teachers’ mathematics content knowledge, pedagogical content knowledge, and pedagogical content beliefs related to the topic.

Together, the sections of the CSM web site were intended to promote teaching as design by providing “‘just in time’ online professional development” (Southern Regional Education Board, 2004) that could help teachers understand teaching as design and “help teachers link their instructional goals to the specific features and affordances of curriculum materials” (M. W. Brown, 2009, p.33).

Table 2 provides a matrix that aligns the sections of the web site with the study’s research questions and identifies the purpose of each section, based on the professional development recommendations of M. W. Brown (2009) and Ball and Cohen (1996) presented in this chapter.
<table>
<thead>
<tr>
<th>Purpose</th>
<th>Research Question #1: Understanding Teaching as Design</th>
<th>Research Question #2: Engaging in Teaching as Design</th>
<th>CSM Web Site Section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Home</td>
<td>Teaching as Design</td>
<td>Getting Started</td>
</tr>
<tr>
<td>Understanding Teaching as Design</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Mathematics Content Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Pedagogical Content Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mathematics Pedagogical Content Beliefs</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Providing Multiple Points of Access</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Employing a “Resource-centric” Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supporting Customization</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Linking Goals to Curriculum Materials</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Emphasizing Assessment</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
The middle and right-hand columns of Table 2 organize the seven major sections of the CSM web site under the corresponding research question (e.g., the Home, Teaching as Design, and Getting Started sections corresponded primarily with Research Question #1). The left-hand column identifies nine specific purposes of the CSM web site.

The first purpose, Understanding Teaching as Design, is self-evident. The next group of purposes – developing teachers’ Mathematics Content Knowledge, Mathematics Pedagogical Content Knowledge, and Mathematics Pedagogical Content Beliefs – was derived from the literature used to establish teachers as decision makers in Chapter 2. Professional development targeting these teacher characteristics was an appropriate purpose for the CSM web site because of their significant impact on teacher practice (see, e.g., Petersen et al., 1989) and their implications for teaching as design (see Chapter 2). The purposes listed in the third layer of Table 2 – providing Multiple Points of Access, employing a “Resource-centric Design,” Supporting Customization, and Linking Goals to Curriculum Materials – were taken directly from M. W. Brown’s recommendations for curriculum materials and professional development discussed in the preceding section. The last purpose – Emphasizing Assessment – represents a synthesis of the recommendations of Ball and Cohen (1996) previously discussed (e.g., listening to and interpreting student responses, analyzing student work samples, and hearing students’ ideas; 1996, p. 7) with two of the essential features of teaching as design identified by the DG: #2) Selecting Assessments Before Lessons; and #5) Using Ongoing Formative Assessment to Guide Instruction. The DG felt it was important to emphasize the value of assessment throughout the CSM web site because, as previously noted, assessment can serve as a catalyst for continuously re-evaluating available resources (Essential Feature #3) in order to match instruction to the established goals and assessments (Essential Feature #4). The remainder of
this chapter details the key features and purposes of each of the seven sections of the CSM web site. Complete screen captures of the CSM web site are included in Appendix D.

**CSM Web Site Section 1: Home**

*Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs*

As the “front door” of the CSM web site, the Home section was crafted to introduce the site through Mission and Vision statements. The mission statement (see Figure 14) had been drafted prior to this study by my school division’s Mathematics Literacy Team, on which I serve along with the two EIS from the research team; we chose to include this statement here because of its focus on mathematics achievement for all students, which, of course, is the ultimate goal of teaching as design. The DG also felt that the statements’ emphasis on the NCTM (2000) Process Standards and its specific mention of the use of formative assessment to guide instruction would frame the subsequent resources within the district’s established goals for mathematics instruction. The vision statement (see Figure 15) was drafted by the DG to pave the way for the site’s teaching as design resources by explicitly stating our belief that teachers are decision makers. The quotes from NCTM (2000) and Shulman (1990) were intended to support the vision statement by emphasizing our view of teachers as users, rather than merely implementers, of curriculum.

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9 Thanks to the 2010-11 MCPS Mathematics Literacy Team: Dr. Lois Graham, Beth MacDonald, Natasha Pappas, Susan Schulz, and Jennifer Smith.
Figure 14. CSM web site excerpt: Home – Mission.

Our Mission
Montgomery County Public Schools strives to promote comprehensive mathematical literacy by providing effective classroom instruction that incorporates intervention and extension opportunities to support all learners.

Our K-12 Mathematics program emphasizes a balance between factual knowledge, procedural fluency, and conceptual understanding. Our instruction consistently provides students with opportunities for problem solving, reasoning and proof, communication, identifying connections, and creating and analyzing multiple representations of mathematical ideas. Our instructional decisions are guided by formative assessment data to ensure that all students receive a high-quality mathematics education.

Figure 15. CSM web site excerpt: Home – Vision.

Our Vision
We believe that our teachers are decision makers who use curriculum materials as tools to meet their instructional goals.

We view teaching as a design activity that requires planning backward from our established goals, identifying essential student understandings, diagnosing our students’ needs, crafting units and lessons to meet those needs, gathering evidence of our students’ progress, and engaging in ongoing analysis and reflection to improve our students' learning.

"A school mathematics curriculum should provide a road map that helps teachers guide students to increasing levels of sophistication and depths of knowledge."
- NCTM (2000)

"The essential value of curriculum is how it permits teachers to adapt, invent and transform as they confront the realities of classroom life."
- Lee Shulman (1990)

CSM Web Site Section 2: Teaching as Design

Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs

The second section of the web site, Teaching as Design, extended the information presented in the Home section by defining the term design and introducing teaching as design through a quote from Wiggins and McTighe (2005; see Figure 16). As with the Home section, the Teaching as Design Section was intended to help teachers understand teaching as design
while raising issues of mathematics pedagogical content belief. A key feature of this section was our assertion that teaching as design is “just good teaching,” found under the heading Our Approach (see Figure 17). As mentioned in Chapter 2, our goal was to present teaching as design as clearly and simply as possible in order to help teachers see that it would not require drastic changes from their current teaching practices. We wanted teachers to understand that the purpose of the CSM web site was not to fix things that they were doing wrong – it was to support the things that they were already doing well.

**Figure 16.** CSM web site excerpt: Teaching as Design – Defining and introducing teaching as design (Merriam Webster Online Dictionary, 2011; Wiggins & McTighe, 2005, p.13).

"Teachers are designers. An essential act of our profession is the crafting of curriculum and learning experiences to meet specified purposes. We are also designers of assessments to diagnose student needs to guide our teaching and to enable us, our students, and others (parents and administrators) to determine whether we have achieved our goals."


**Figure 17.** CSM web site excerpt: Teaching as Design – Our Approach.

**Our Approach**

Some of these authors have also created professional development systems intended to promote teaching as design (e.g., *Understanding by Design*). However, instead of implementing one of these complex (and often rather prescriptive) systems for our teachers, we're taking a simpler approach.

The basic ideas of teaching as design are actually pretty straightforward, and we believe that most teachers would consider these ideas to be "just good teaching". We also believe that, with a little background information and a few simple supports, most teachers can begin implementing these ideas into their mathematics teaching fairly quickly.
CSM Web Site Section 3: Getting Started

*Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs; Providing Multiple Points of Access; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment*

The Getting Started section of the web site contained the majority of our content explaining teaching as design. It was organized around the five essential features of design identified by the DG during the Analysis phase of the study. Since detailed descriptions of those features have already been provided in Chapter 2, they will not be repeated here. Instead, I will address the purposes of the other components of the Getting Started section.

We began the section by identifying the overall goals for the CSM web site, which were based on the study’s research questions (see Figure 18). The decision to state our goals explicitly was based on the recommendations for transparency (Davis & Krajcik, 2005) discussed previously in this chapter; our hope was to minimize any misconceptions among our users regarding our motives.

**Figure 18.** CSM web site excerpt: Getting Started.

The content explaining the essential features of teaching as design was organized to provide multiple points of access for our users by offering what we believed was a brief, clear explanation of each essential feature, accompanied by links to supplemental resources. This way, users who were already familiar with concepts of teaching as design could move through
the Getting Started section fairly quickly, while those who were new to these concepts (as well as those interested in learning more) could explore the additional resources as needed. This content was also intended to support customization (see Essential Feature #3: Reviewing Available Resources), help teachers link goals to materials (see Essential Features #1: Planning Backward from Learning Goals; and #4: Matching Instruction to Goals and Assessments), and emphasize the importance of assessment (see Essential Features #2: Selecting Assessments Before Lessons; and #5: Using Ongoing Formative Assessment to Guide Instruction).

We concluded the Getting Started section by asserting that engaging in teaching as design would not represent a major change in practice for most teachers, but instead would constitute a subtle shift in the way they approached their planning (see Figure 19). We re-emphasized our efforts to distill the extensive content of the prominent teaching as design resources down to a few relatively simple steps, and we encouraged users to “give it a whirl” by exploring the Unit Checklist found in the next section of the web site.

**Figure 19.** CSM web site excerpt: Getting Started – Ready to give it a whirl?

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**Ready to Give it a Whirl?**

*Just do it. - Nike (1988)*

Okay, so we realize that’s a lot of information, but seriously: Other than asking you to create your assessments before you plan your instruction, is there really anything that earthshaking here? These are fantastic ideas, but their beauty lies in their simplicity.

The next section will introduce you to a planning tool to help you get started.

*The Unit Planning Checklist*

*(For the record, we should mention that Wiggins & McTighe also thought it was clever to quote the Nike slogan in the "Getting Started" section of their book, *Understanding by Design*; we’d like to point out, however, that they didn’t get around to discussing how to get started until page 322 - in the Afterword!)*
CSM Web Site Section 4: The Unit Checklist

*Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs; Providing Multiple Points of Access; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment*

The Unit Checklist served as a bridge between the two goals of the CSM web site, providing a means for teachers to begin engaging in teaching as design that could also expand their understanding of teaching as design by modeling what it looks like in practice. Our goal was to create a single tool that could be used flexibly by teachers of all levels of experience and skill, reminding them of the essential features of teaching as design without being overly prescriptive.

**Why a Checklist?**

I got the idea for using a checklist after reading *The Checklist Manifesto* by Atul Gawande (2009). Gawande analyzed the use of checklists by pilots and structural engineers, utilizing his findings to help develop a Surgical Safety Checklist (World Health Organization, 2009) that has been field testing in hospitals worldwide with positive results. He noted the potential of checklists for improving human performance because “they remind us of the minimum necessary steps and make them explicit. They not only offer the possibility of verification but also instill a kind of discipline of higher performance” (2009, p.36).

Citing the work of Glouberman and Zimmerman (2002), Gawande also distinguished between simple, complicated, and complex tasks (2009, p. 49). Simple tasks are ones like following a recipe to bake a cake; these tasks can be replicated consistently by applying the same techniques in the same order each time. Complicated tasks, like sending a rocket to the moon, require careful timing and coordination among skilled practitioners to complete multiple, comparatively simpler tasks. As with simple tasks, once a complicated task has been completed successfully, it can be replicated by following the same procedures. Complex tasks, however,
require skilled practitioners to complete multiple complicated tasks under unique circumstances – for example, raising a child or performing emergency surgery. While practitioner experience and knowledge of appropriate techniques are necessary for the successful completion of complex tasks, these cannot be applied in a formulaic way to guarantee a successful result, because each complex task represents a unique situation (i.e., there is no recipe for raising all children). It struck me that teaching a child to understand a mathematics concept is just such a complex task: While I may have experience successfully teaching a concept to students, and I may know many different instructional strategies that are helpful, every child responds differently to instruction, making it impossible to repeat the exact same procedure with each one.

Gawande (2009) made a convincing argument for the value of checklists in improving human performance of complex tasks. He asserted that, in addition to identifying “the minimum necessary steps” (p. 36), checklists for complex tasks should identify “communication tasks” (p. 65) for practitioners. He noted the common practice in skyscraper construction of using two types of checklists: a construction schedule listing every building task, from pouring concrete to painting drywall; and a submittal schedule of communication tasks required before proceeding to subsequent phases of construction (p. 65). This idea of requiring communication tasks to address unexpected issues that arise in complex situations is a powerful one:

…the way that project managers dealt with the unexpected and the uncertain was by making sure the experts spoke to one another – on X date regarding Y process. The experts could make their individual judgments, but they had to do so as part of a team that took one another’s concerns into account, discussed unplanned developments, and agreed on the way forward. While no one could anticipate all the problems, they could foresee where and when they might occur. The checklist therefore detailed who had to
talk to whom, by which date, and about what aspect of construction – who had to share
(or “submit”) particular kinds of information before the next steps could proceed.
(Gawande, 2009, pp. 65-66)

I felt strongly that this idea also applied to teaching: Just as it is no longer practicable for a single
master builder to construct a skyscraper, today’s teachers no longer act in isolation; they must
communicate regularly with a wide range of stakeholders (parents, team teachers, counselors,
special education staff, administrators, etc.) in order to be successful. A checklist could remind
teachers of the importance of such communication without prescribing teachers’ actions.

**Our Checklist.**

Because I suspected that a checklist could play an important role in helping teachers
engage in teaching as design, I included *The Checklist Manifesto* among the DG’s readings
during the Analysis phase. Through our subsequent discussions, the DG agreed that a checklist
was a potentially useful tool aligned with our view of teachers as decision makers. As Gawande
put it, “the philosophy is that you push the power of decision making out to the periphery and
away from the center. You give people the room to adapt, based on their experience and
expertise. All you ask is that they talk to one another and take responsibility” (p. 73).

Creating the Unit Checklist (see Figure 20) took longer than any other feature of the
CSM web site and required numerous discussions and revisions over the course of the
Development phase. The content of the checklist was based on the essential features of teaching
as design derived from the work of Wiggins and McTighe (2005) and Stepanek et al. (2011) in
Chapter 2. We began developing the checklist by consulting Gawande’s (2010) Checklist for
Checklists and selecting several of the suggested criteria to guide our work:

- having clear, concise objectives for the checklist;
• adding items to improve communication among users;
• utilizing natural break points in workflow (pause points);
• using simple sentence structure and basic language;
• having a simple, uncluttered, and logical one-page format. (Gawande, 2010)

In addition, the structure of the study allowed us to incorporate Gawande’s suggestions for validating a checklist by testing it with front line users to ensure that it fit the flow of teachers’ work and allowed errors to be detected at a time when they could still be corrected (2010).

We met the first criterion, establishing clear, concise objectives for the checklist, by aligning the Unit Checklist with the study’s research questions that we had included at the top of the Getting Started section of the CSM web site: helping teachers begin to engage in teaching as design while expanding their understanding of teaching as design by modeling what it looks like in practice. We addressed the second criterion, including items to improve communication among users, through the Plan for Available Support Staff section located in the During column of the checklist. We included this reminder directly below the sections on data analysis and instructional grouping in the hope of promoting communication with other stakeholders in an effort to address these issues throughout the unit. The three-column format of the checklist was intended to utilize the natural pause points of planning and teaching an instructional unit by distinguishing tasks that should occur Before, During, and After the unit. Finally, we considered the remaining criteria for language and formatting throughout our revision process to create a final product that we believed was logically-organized and simple to use.
Figure 20. CSM web site excerpt: Unit Checklist.

**Not Just Another Lesson Plan Template**

Apparently, a lot of people think that the best way to get teachers to change what they do is to require prescribed lesson plans: Googling "lesson plan template" yields 3,650,000 results in 0.15 seconds, so creating yet another one doesn't seem like it would be very helpful.

We believe that our teachers are already doing a great job with planning and teaching – we just want to shift our teachers' thinking a little during the process.

The purpose of this Unit Planning Checklist is to help you remember to think about those Essential Features of Teaching as Design. You can download the checklist here.

**Unit Planning Checklist**

<table>
<thead>
<tr>
<th>Before</th>
<th>During</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establish Learning Goals</td>
<td>Assess Student Learning</td>
<td>Assess Student Learning</td>
</tr>
<tr>
<td>□ Identify the big idea(s)</td>
<td>□ Collect formative assessment data</td>
<td>□ Collect summative assessment data</td>
</tr>
<tr>
<td>□ Students should understand...</td>
<td>□ Analyze student understandings</td>
<td>□ Analyze student understandings</td>
</tr>
<tr>
<td>□ Students should know...</td>
<td>□ Plan for re-teaching</td>
<td>□ Plan remediation for struggling students</td>
</tr>
<tr>
<td>□ Students should be able to...</td>
<td>□ Review/revise remaining lessons</td>
<td></td>
</tr>
<tr>
<td>□ Review VDOE Curriculum Framework</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Select/Modify/Create Assessments</td>
<td>Consider Instructional Grouping Options</td>
<td>Reflect on the Unit</td>
</tr>
<tr>
<td>□ Pre-assessments</td>
<td>□ Whole class</td>
<td>□ Which lessons were successful?</td>
</tr>
<tr>
<td>□ Formative assessments</td>
<td>□ Groups</td>
<td>□ Which lessons need to be revised?</td>
</tr>
<tr>
<td>□ Summative assessments</td>
<td>□ Centers</td>
<td>□ Which assessments were helpful?</td>
</tr>
<tr>
<td>□ Variety of assessment formats</td>
<td>□ One-on-one</td>
<td>□ Which assessments need to be revised?</td>
</tr>
<tr>
<td>Review Available Resources</td>
<td>Plan for Available Support Staff</td>
<td>□ Review lesson sequence</td>
</tr>
<tr>
<td>□ Textbook materials</td>
<td>□ Special Education / RTI</td>
<td></td>
</tr>
<tr>
<td>□ Supplementary materials</td>
<td>□ Instructional Specialist</td>
<td></td>
</tr>
<tr>
<td>□ Enhanced Scope &amp; Sequence</td>
<td>□ Gifted Resource Teacher</td>
<td></td>
</tr>
<tr>
<td>Select Lessons/Activities</td>
<td>□ Tutors</td>
<td></td>
</tr>
<tr>
<td>□ Logical sequence</td>
<td>□ Pre-service teachers</td>
<td></td>
</tr>
<tr>
<td>□ Connections to learning goals</td>
<td>□ Volunteers</td>
<td></td>
</tr>
<tr>
<td>□ Connections to SOL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is important to note that we did not attempt to incorporate every suggestion from the Checklist for Checklists, in particular Gawande’s assertion that “a checklist is not a teaching tool” (2010). We believed that the Unit Checklist could be a practical tool that also provided
professional development by alerting teachers to features of teaching as design with which they needed additional support. For example, a teacher consulting the Assessment section of the Before column might decide to consult the supplemental content on using a variety of assessments located in the Getting Started section of the CSM web site. Consequently, we chose to include items on the checklist which may have been new to some teachers. We believed that this deviation from Gawande’s recommendation was appropriate, because the time frame of teaching differs from that of other complex tasks. For example, tasks such as landing an airplane or performing surgery require practitioners to make life-or-death decisions in a matter of minutes or even seconds. There is literally no time for a checklist to serve as a teaching tool in these situations; they are strictly for preventing costly errors. Teaching, on the other hand, is a complex task that unfolds comparatively slowly, allowing teachers the luxury of engaging in a level of on-the-job training that is not afforded to pilots or surgeons. My long-range vision for the Unit Checklist was that it could eventually be used collaboratively by teams of teachers to identify common learning needs and guide their own programs of professional study.

CSM Web Site Section 5: Resources by Topic

_Purposes: Mathematics Content Knowledge; Mathematics Pedagogical Content Knowledge; Mathematics Pedagogical Content Beliefs; Emphasizing Assessment_

The Resources by Topic section was included to make the CSM web site easier to use by allowing navigation to all of the instructional resources from one page (see Figure 21). Eventually, this section could be expanded to include resources to support other topics; for the purposes of this study, it linked only to the Introducing Multiplication and Division resources.
This section also contained the first of six teacher professional development videos that I produced for the CSM web site in collaboration with the DG. The videos were created in response to a specific finding of the spring 2010 needs assessment indicating that “teachers desire resources related to the teaching and learning of mathematics that will help them better understand children’s mathematical development and guide their instruction to promote student understanding of key concepts” (Schulz, 2010). The six videos, which range from four to ten minutes in length, were intended to develop teachers’ mathematics content knowledge, pedagogical content knowledge, and pedagogical content beliefs. Each video utilized narrated screen recordings of animated SMART Notebook presentations to address a single idea related to multiplication and division. By providing multiple shorter videos targeting specific ideas, users would be able to select the videos that matched their needs.

This first video, Why We Need to Teach the Big Ideas, was intended to provide an illustration supporting our prior assertion (see Chapter 2, Essential Feature #1) that teaching students the “how” of mathematics without helping them understand the “why” can have unintended consequences. In this video, I shared an activity that I have used with fourth- and fifth-grade students to assess their understanding of the meaning of multiplication and discussed
examples of common misconceptions. I hoped to help teachers see the need for establishing learning goals that identify what students should understand, not just what they should be able to do (Wiggins & McTighe, 2005).

**CSM Web Site Section 6: Introducing Multiplication and Division**

*Purpose: Mathematics Content Knowledge; Mathematics Pedagogical Content Knowledge; Mathematics Pedagogical Content Beliefs; Multiple Points of Access; Emphasizing Assessment*

As identified in Chapter 2, the first essential feature of teaching as design is planning backward from learning goals. The content related to this feature in the Getting Started section of the site included three questions that teachers should consider when establishing their learning goals (Wiggins & McTighe, 2005):

- What are the big ideas of elementary mathematics that I want to address?
- What do my students need to understand about those big ideas?
- What do they need to know and be able to do?

The Introducing Multiplication and Division section of the CSM web site provided professional development resources explaining what students should understand, know, and be able to do when beginning to learn about multiplication and division.

As we began to design the mathematics content resources intended to help teachers begin to engage in teaching as design, we quickly learned that establishing appropriate learning goals is a deceptively challenging task that requires significant mathematics content knowledge. Reconsidering Wiggins and McTighe’s (2005) *Understanding by Design*, we now appreciated why the authors had devoted more than 150 pages to issues related to learning goals. The classroom teachers in the DG observed that placing the responsibility on classroom teachers for identifying what students should understand, know, and be able to do for every topic was likely to deter most teachers from attempting teaching as design; we suspected that the majority of our
division’s elementary teachers lacked the mathematics content knowledge to establish appropriate goals, and that those who did have the requisite knowledge would be overwhelmed by time required to do so. We decided that we would identify and explain the learning goals within the CSM web site.

This decision represented the essence of our work to simplify teaching as design: We believed that identifying the overarching learning goals for our teachers – shifting this task from an instructional responsibility to a curricular leadership responsibility – could make teaching as design more accessible by allowing teachers to focus on evaluating curriculum materials, designing lessons, and assessing their students’ progress toward those goals.

To establish the learning goals for multiplication and division, we consulted NCTM’s *Principles and Standards for School Mathematics* (2000) and *Curriculum Focal Points* (2006), CCSSO’s *Common Core Standards for Mathematics* (2010), and the Virginia Standards of Learning for Mathematics (2009). After nearly two weeks of intensive discussions, we agreed on the learning goals presented in Figure 22.
The Big Idea

**Equal Groups:** Whole number multiplication and division are related operations used to describe situations involving equal groupings of objects.

**Students should understand that...**

1. Multiplication and division are closely related to each other.
2. Multiplication involves equal groups.
3. Division involves equal groups.
4. Multiplication and division describe the same situation, just with different unknowns:
   - Multiplication - "unknown-product" problems
   - Division - "unknown-factor" problems

**Students should know that...**

1. Each number in a multiplication or division number sentence has meaning depending on the context: the **number of groups**, the **number of objects in each group**, and the **total number of objects**.
2. Division involving equal groups has two meanings: **fair-sharing** (divvying up) to find an unknown group size; and **partitioning** (measuring out equal-sized groups) to find an unknown number of groups.
3. Multiplication and division can be represented by **equal groups, arrays, and equal-sized "jumps" on a number line (skip-counting)**.

**Students should be able to...**

- **Interpret products** of whole numbers.
- **Interpret whole-number quotients** of whole numbers.
- Use multiplication and division to **solve word problems** involving equal groups, arrays, and number lines.
- **Determine the unknown whole number in a multiplication or division equation** relating three whole numbers.

Interestingly, we realized after the fact that we had organized these learning goals so that they corresponded to three of the documents that we consulted in creating them: The Big Idea and what Students Should Understand were based on NCTM’s *Principles and Standards for School Mathematics* (2000); what Students Should Know was derived from NCTM’s *Curriculum Focal Points* (2006); and what Students Should Be Able to Do was excerpted from
CCSSO’s *Common Core Standards for Mathematics* (2010). We had conducted a thorough analysis of the mathematics content of these sources to identify our learning goals, but had not explicitly discussed the relationships between the three documents. In retrospect, the unexpected correspondence of our goals to three individual sources makes perfect sense based on the intent of each document: *Principles and Standards* outlined broad curriculum goals; the *Focal Points* narrowed the *Standards* down to grade-level content; and the *Common Core Standards* identified specific grade-level objectives.

This section of the web site also contained four of the professional development videos described previously. This first video (The Big Idea) explained the big idea and elaborated on what students should understand about multiplication and division, specifically that they are related operations involving equal groups and that they can be used to describe the same situation. The second and third videos (Know: Part 1; Know: Part 2) addressed what students should know, focusing on the contextual meanings of numbers in multiplication and division equations, the difference between partitive and quotative division, and ways of modeling the two operations. The fourth video (Be Able To) explained what students should be able to do, including interpreting products, solving word problems, and determining an unknown whole number in an open multiplication or division sentence. The goal of these videos was to help teachers understand what students should know about multiplication (mathematics content knowledge) while identifying important instructional approaches (mathematics pedagogical content knowledge) and the rationale behind them (mathematics pedagogical content beliefs).
CSM Web Site Section 7: Should Be Able To

*Purposes: Multiple Points of Access; Employing a “Resource-centric” Design; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment*

The final section of the CSM web site consisted of four separate web pages, each devoted to one of the things students should Be Able To (BAT) do that were identified in the Introducing Multiplication and Division section. The primary purpose of these pages was to address M. W. Brown’s recommendation for employing a resource-centric approach to the design of curriculum materials while linking the learning goals to curriculum materials and supporting customization.

We began each BAT page by identifying any related state and national standards (see Figure 23) so that teachers could see how a single BAT develops across grade levels. The remainder of each page identified relevant assessment and teaching resources.

**Figure 23.** CSM web site excerpt: Should Be Able To – Related Standards.

**Related Standards**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 SOL K.4.1, 2, 4</td>
<td>Counting by 1's; skip counting by 2's, 5's, and 10's; recognizing even and odd numbers.</td>
</tr>
<tr>
<td>2009 SOL 3.2</td>
<td>The student will recognize and use the inverse relationships between addition/subtraction and multiplication/division to complete basic fact sentences. The student will use these relationships to solve problems.</td>
</tr>
<tr>
<td>2009 SOL 3.6</td>
<td>The student will represent multiplication and division, using area, set, and number line models, and create and solve problems that involve multiplication of two whole numbers, one factor 99 or less and the second factor 5 or less.</td>
</tr>
<tr>
<td>Common Core Standard 3.OA.3</td>
<td>Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.</td>
</tr>
</tbody>
</table>

It is important to point out that, during the middle of the Development phase of the study, our school district adopted a new elementary mathematics curriculum program that would be put in place at the beginning of the next academic year. This created a tough choice for the DG between organizing the BAT pages around our existing program or around the new program.
We elected to focus on the new program so that the BAT resources could potentially be re-used in the future. The impact of this decision will be discussed in Chapter 7.

**Figure 24.** CSM web site excerpt: Should Be Able To – Assessments.

<table>
<thead>
<tr>
<th>Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Examples:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>6 x 3 = ?</td>
</tr>
</tbody>
</table>

_Houghton-Mifflin Expressions Assessment Resources_

G3 Homework 7.4

**Assessment Suggestions**

**Informal Checks for Understanding:** When working with fact triangles, instead of asking students to find a missing number, just cover up one of the numbers and ask students to write the equation that they see (note that some students may see a multiplication equation while others may see a division equation for the same example).

**Academic Prompts:** Ask students to choose a multiplication/division fact family and then write four different open number sentences (i.e., equations with a missing number - see examples above) for that fact family.

**Quiz and Test Items:** [MCPS Sample Items](#)

The assessment component (see Figure 24) of each BAT page provided an example of how the BAT might be assessed, identified related assessment resources within the new curriculum program, and provided sample quiz and test items. We also included suggestions for how these resources might be used. Our goal was to emphasize the importance of assessment by placing the assessment resources in front of the teaching resources and to provide multiple points of access by annotating the resources. We envisioned that some users would take the assessment resources and use them “as is” while other users could adapt the resources to suit their needs.

Similarly, the teaching resources component (see Figure 25) of each BAT page identified relevant teaching resources within the new curriculum, annotated to explain their purposes and
possible uses. These resources were intended to help teachers link the learning goals to the instructional materials in the new curriculum program. We also hoped to support customization by identifying many different resources from which teachers could choose when designing an instructional unit.

**Figure 25.** CSM web site excerpt: Should Be Able To – Teaching Resources.

### Teaching Resources

**Houghton-Mifflin Expressions Teaching Resources**

**Related Units:**
- Grade 2 Unit 13 (p. 953A)  
- Grade 3 Unit 7 (p. 457A)  
*Once the online TE opens, type in the desired page number.*

**Some Suggestions:**
- **Grade 2 Unit 13**
  - Notice that the "Keeping Skills Sharp" section of each lesson (e.g., p. 953) has students practice important skills such as skip counting and drawing arrays and equal groups models on the 120 poster.
  - Lessons 1-3 focus on equal groups models. Students examine the patterns for skip counting by 2's, 3's, and 4's and make connections to between skip counting and multiplication equations. Check out "The Learning Classroom" (sidebar, p. 962) and Differentiated Instruction Extra Help (sidebar, p. 968).
    - **Student Activity Book p. 418**  
    - **p. 419**  
    - **p. 423**  
    - **p. 424**  
    - **p. 427**  
    - **p. 428**
  - Lessons 4-5 focus on array models. Check out "Teaching Note - Language and Vocabulary" (sidebar, p. 975) and "Teaching Note - Watch For" (p. 976).
    - **Student Activity Book p. 432**  
    - **p. 433**  
    - **p. 434**

**Online Resources:**

**Soar to Success**
- **Topic 12. Multiplying Whole Numbers** - Lesson 19: Use Repeated Addition to Multiply...
- **Topic 12. Multiplying Whole Numbers** - Lesson 23: Use Arrays to Multiply...

**Mega Math**
- **Fraction Action. Number Line Mine** - D. Multiplication Facts
- **Numberopoius. Carnival Stories** - S. Multiplication Stories

**Destination Math**
- **Repeated Addition and Arrays**
Summary

This chapter described the Development phase of the study, outlining the design process and discussing the rationale behind our design decisions. It also aligned the seven sections of the CSM web site with study’s research questions, identified the purposes of each section, and provided a detailed description of the web site. The following chapter describes the structure of the study.
Chapter 6: Structure of the Study

This chapter presents the methods used to carry out the study. It begins with descriptions of the setting and the research team, followed by a discussion of the purpose, research questions, and significance of the study. The structure of the study is then outlined, including the methods of data collection and analysis as well as a reflection on my role as a practitioner-researcher. The chapter concludes with an examination of the trustworthiness of the study, addressing the issues of truth value, rigor, and usefulness.

As discussed in Chapter 1, this exploratory study originated from a perception among my district’s elementary mathematics teachers of a conflict between the adopted curriculum program and the state standards. In seeking a way to resolve this conflict, I began by investigating existing theory regarding teachers’ use of curriculum materials and the role of the mathematics supervisor, resulting in this study’s focus on promoting teaching as design (see Chapter 2) through the use of Curriculum Support Materials (CSM; see Chapter 5). This chapter describes the structure of the study, including the methods of data collection and analysis. I begin with a description of the setting and the research team.

Setting

For the past four years, I have served as Mathematics Supervisor for Montgomery County Public Schools (MCPS), located in southwestern Virginia. Montgomery County encompasses nearly 400 square miles and has approximately 90,000 residents. The county includes the towns of Blacksburg and Christiansburg, which make up about two thirds of the county’s population, as well as several smaller rural communities. The Town of Blacksburg is home to Virginia Tech, a university with more than 30,000 full-time students.
MCPS serves approximately 9,700 students, about 38% of whom receive free/reduced price lunch. Approximately 86% of the students are White, 6% are Black, 3% are Asian/Pacific Islander, and 2% are Hispanic. MCPS’ 19 schools include four high schools, four middle schools, and eleven elementary schools spread across four attendance zones. MCPS employs approximately 240 elementary classroom teachers to serve the approximately 4,400 students in grades K-5. In addition, MCPS employs four Elementary Instructional Specialists (EIS) whose responsibilities include providing teachers with coaching and professional development to support the teaching and learning of reading and mathematics. Three of these EIS have earned master’s degrees in K-8 mathematics curriculum and instruction and are endorsed in the state of Virginia as Mathematics Specialists for Elementary and Middle Education.

From 2001-2011, MCPS used the Standards-based curriculum program (see Chapter 1) *Everyday Mathematics* (University of Chicago School Mathematics Project, 2004) as the principal resource for mathematics instruction in grades K-5. Implementation of this program was supported with extensive funding from a five-year National Science Foundation (NSF) grant\(^\text{10}\) administered through Virginia Tech.

**Research Team**

I served as the lead researcher and facilitator of a team of practitioners consisting of six elementary classroom teachers and two elementary instructional specialists (EIS) from my school division. Team members served on a volunteer basis and were awarded licensure recertification points for their work. The classroom teachers were recruited based on their reputations within the district as successful mathematics teachers, which I corroborated with their building principals and the EIS who work with these teachers on a regular basis. I also

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\(^{10}\) Patty, C. W., & Wilkins, J. L. M. (2000). *Systemic Reform of Mathematics K-5 for Virginia*. Local Systemic Change Grant from the National Science Foundation, (5 years, $2,800,000).
considered the teachers’ enthusiasm for participating in the study and their ability to make the necessary time commitments in making my selections. Three of these classroom teachers had participated in the focus group interview conducted as part of the spring 2010 needs assessment (see Chapter 1) and expressed interest in continuing with the project. Collaborating with these successful and enthusiastic teachers was essential for completing the challenging design, development, and evaluation work that this study entailed. The EIS were selected for their mathematics content knowledge, pedagogical content knowledge, experience developing curriculum resources and assessments, and for their experience delivering teacher professional development. My wife, Susan Schulz, served on the research team as one of the two EIS and was a key contributor to the study.

The eight members were divided into two smaller work groups of four members each: a Design Group and an Implementation Group. The Design Group, consisting of two fourth grade classroom teachers and the two EIS, was responsible for the design, development, and evaluation of the CSM. The Implementation Group, consisting of four second grade teachers from four different elementary schools, tested the CSM and provided feedback to the Design Group. The work of the Design Group (DG) occurred throughout all four phases of study, while the work of the Implementation Group (IG) occurred only during the last two phases of the study.

The EIS were included in the DG because their strengths (as identified above) were well-suited for the design and development of the CSM. I chose to pilot test the CSM at second grade for two reasons: the timing of the study within the academic year, and my desire to continue working with interested members of the needs assessment focus group. Because the pilot testing occurred in May, working with second grade teachers avoided conflicts with the 3rd–5th Grade teachers’ preparations for end-of-year state testing. In addition, two of the more enthusiastic
members of the spring 2010 needs assessment focus group currently teach second grade, so selecting this grade level allowed these teachers to continue to participate in the project. It also happened that two of our districts’ most highly regarded teachers – known for their exceptional pedagogical content knowledge and frequently called upon to lead professional development – teach second grade, and I was fortunate that they both agreed to join the research team. The strengths of these four teachers, combined with their interest in improving our mathematics curriculum resources, made them particularly well-suited for critically evaluating the CSM and providing specific feedback.

**Reflecting on My Role**

Before conducting this study, I carefully considered the potential impact of the dual roles that I would play. Although I was the lead researcher, my primary role throughout this process remained that of Mathematics Supervisor for Montgomery County Public Schools, and, as a practitioner-researcher, it was important for me to remember that I was first and foremost a practitioner. I do not believe that the tensions between these roles compromised my research in any way; on the contrary, as I described in Chapter 3, I believe that my role as mathematics supervisor made me particularly well-positioned to conduct the study. I did, however, recognize the need to reflect on these tensions. Rossman and Rallis (2003) noted the importance of such self-reflection when they stated that “qualitative researchers recognize the importance of reflecting on who they are and how this affects their research” (p. 10). Patton (2002) described such reflexivity as “a way of emphasizing the importance of self-awareness, political/cultural consciousness, and ownership of one’s perspective” (p. 64).

I maintained a research journal throughout the study, in which I reflected on the interplay of my roles, including their impact on my relationships and interactions with the members of the
research team (my wife, in particular). These reflections were intended to help me paint an accurate picture of the research process, which is a central requirement of reporting the findings of design research (Collins et al., 2004).

My desire for reflexivity influenced my use of voice in writing this dissertation. Chapters 1–4 are written primarily in a passive voice, since they comprise the introduction and review of the literature that are common to traditional dissertations. Chapters 5–8, however, are written in a more active voice, blending first- and third-person, since these chapters describe the design research process. Patton (2002) supported the use of the first-person voice in reporting qualitative research, asserting that “a credible, authoritative, authentic, and trustworthy voice engages the reader through rich description, thoughtful sequencing, appropriate use of quotes, and contextual clarity so that the reader joins the inquirer in the search for meaning” (p. 65). I believe that utilizing a blend of first- and third-person voice can, as Rossman and Rallis (2003) recommended, “allow [me] to reveal [myself], to articulate [my] biases” (p. 337).

However, I also believe that the exploratory nature of this study greatly reduced any potentially negative impact of my biases, because the purpose of the study (see next section) was to understand what features of the CSM seemed to work (and didn’t seem to work) and why, rather than trying to gather evidence that the CSM was effective. As will be demonstrated in Chapter 7, the Testing and Initial Reflection phases of the study produced a critical examination of the potential strengths and weaknesses of the CSM.

Purpose of the Study

This study aimed to explore the potential of CSM for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design. Because this was an exploratory study, it focused on the design,
development, and pilot testing of the CSM, and did not attempt to evaluate a full-scale implementation. This study did not seek to obtain conclusive evidence of the CSM’s effectiveness, but instead attempted to learn about their potential (McKenney, 2001) for promoting teaching as design. The findings of this study will inform the revision of the piloted CSM, guide the design of future CSM, and lay the groundwork for future study of their effectiveness.

**Research Questions**

The study was guided by two research questions:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

My desire to explore the “how” and the “why” of the impact of the characteristics of the CSM was implicit in these questions.

**Significance of the Study**

This study aimed to extend M. W. Brown’s (2009) work with science curriculum materials by developing and evaluating resources and organizational structures specific to the teaching of elementary mathematics as design. By identifying features of the CSM that have potential for promoting teaching as design, the study could open the door for further development and evaluation work, eventually leading to the district-wide implementation and evaluation of the CSM. In addition, the principles of teaching as design can be applied to any subject and with any age student (Wiggins & McTighe, 2005), so the promising features of the mathematics CSM could potentially be used to guide the development of similar resources for middle and high school mathematics, as well as for other content areas.
Structure of the Study

This study employed a design research approach to trace the design, development, and evaluation of the CSM in order to explore their potential for developing elementary mathematics teachers’ understanding of teaching as a design activity and for supporting those teachers in engaging in teaching as design. The intent was to design CSM that could introduce the concept of teaching as design and then serve as an intermediary between teachers and curriculum materials to develop teachers’ understanding of the purposes and possible uses of the materials and informing their decisions to offload, adapt, and improvise with those materials (M. W. Brown, 2009). These goals were consistent with two of the outputs of design research identified by McKenney et al. (2006): curricular products and professional development. In addition, the characteristics of design research, specifically its focus on use, context, and collaboration with practitioners, made it an appropriate choice for this study.

The study was conducted in four phases based on a modified version of Reeves’ (2006) model of the design research cycle (see Figure 1): Analysis, Development, Testing, and Initial Reflection. The phases of the study were inherently sequential and each phase was completed before the next phase began. For example, the Development Phase had to be completed before the CSM could be tested, and the Testing phase had to be completed before the Initial Reflection phase could begin. The study took just over four months to complete, with the Analysis and Development phases lasting for approximately seven weeks each, and the Testing and Initial Reflection phases lasting for approximately two weeks each. The work of the DG and IG ended after the Initial Reflection phase, while my individual efforts continued as I completed the data analysis and submitted the findings to the individual research team members for confirmation.
The four phases of the study are outlined below; Figure 26 displays a time line of the study’s major tasks in the form of a Gantt chart.

**Figure 26.** Time line of the study.

![Implementation Time Line](image)

**Phase 1: Analysis.**

During the Analysis phase, the DG collaborated to explore, clarify, and define the problem of promoting mathematics teaching as design. Such collaboration is a key component of design research, because, as Herrington (2010, March) noted, practitioners can provide valuable insight into the research problem.

Our work during this phase focused on the development of a common understanding among DG members of teaching as a design activity. Actions included the reading and discussion of relevant literature, the sharing of personal experiences of planning and teaching
mathematics, and the identification of the features of teaching as design that we viewed as essential for helping teachers understand the concept. The process and outcomes of this phase were described in detail at the end of Chapter 2.

**Phase 2: Development.**

As presented in Chapter 5, in the Development phase, the DG began by “interrogating the literature” in search of existing theory to inform the design (Herrington, 2010, March) – including the content, organization, and delivery – of the CSM. Recommendations by Ball and Cohen (1996) and M. W. Brown (2009) guided our decisions regarding the organization and delivery of the CSM. The mathematics content decisions were informed by NCTM’s *Principles and Standards for School Mathematics* (2000) and *Curriculum Focal Points* (2006), CCSSO’s *Common Core Standards for Mathematics* (2010), and the Virginia Standards of Learning for Mathematics (2009) as we identified what students should understand about the concept, what teachers need to understand about the concept, and effective ways of teaching the concept and assessing student learning. The Development phase and the resulting CSM were described in detail in Chapter 5.

The data collection instruments used in the Testing and Initial Reflection phases of the study were also developed and refined during this phase, including the Planning and Teaching Logs, the Individual Interview questions, the post-unit Questionnaire, and the two Focus Group Interview protocols. These instruments are described in detail in the Data Collection and Analysis section of this chapter, which follows the current description of the phases of the study.

**Phase 3: Testing.**

Once the prototype CSM had been developed, the IG tested the resources, using them as they planned and taught a 10-day unit of instruction addressing the identified concept. Before
teaching this pilot unit, the IG teachers were asked to log their mathematics planning and
teaching activities for a 10-day period to provide a baseline depiction of their current teaching
behaviors. I then interviewed the four IG members individually, asking them to describe and
reflect upon their mathematics teaching. After these interviews, the DG met with the IG to
present and explain the CSM. The IG teachers then began the pilot unit, maintaining a second
planning and teaching log during the unit and completing a questionnaire after the unit asking
them to describe and reflect upon their experiences. Additional information about the Testing
phase is included in the Data Collection and Analysis section of this chapter.

Phase 4: Initial Reflection.

A focus group interview of the IG, facilitated collaboratively by the lead researcher and
the members of the DG, was conducted after the completion of the pilot unit. The goal was to
understand how the teachers used the CSM, as well as their perceptions of the CSM’s
effectiveness in helping them understand teaching as design and supporting them in engaging in
teaching as design. In addition, the interview sought to identify the strengths and weaknesses of
the CSM and obtain recommendations for their improvement. As the primary data source for
evaluating the CSM, the transcription of this interview was analyzed and discussed by the
Design Group as part of a second focus group interview conducted to collect feedback on the
overall outcomes of study. The findings of the Initial Reflection phase are discussed in Chapter
7.

Data Collection and Analysis

As I pointed out in Chapter 4, design research’s focus on generalizing beyond the original
intervention distinguishes it from formative evaluation. However, the Testing phase of this study
was essentially a formative evaluation of the CSM, since formative evaluations are “typically
conducted for the purposes of program or product improvement by in-house staff” (Russ-Eft & Preskill, 2009, p. 18, referring to the work of Scriven [1967]) and this exploratory study, while intended to inform existing theory in the long run, did not aim to collect conclusive evidence of the effectiveness of the CSM. As a result, the data collection methods of this study were selected based on their appropriateness for use in formative evaluations.

Russ-Eft and Preskill (2009) noted that “an important factor is selecting data collection methods is the evaluator’s key questions” (p. 215) and that “for each evaluation question, [the evaluator] should consider which data collection method or methods could best obtain the needed information” (p. 215). This study’s research questions served as the key questions for the formative evaluation of the CSM conducted during the Testing and Initial Reflection phases, guiding my selection of data collection methods:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

Because the goal of these questions was to capture the IG teachers’ insights into the strengths, weaknesses, and potential usefulness of the CSM, I chose five qualitative data sources to address these questions:

- Planning and Teaching Log #1 (IG; prior to Individual Interview)
- Individual Interview (IG; after completing Planning and Teaching Log #1)
- Planning and Teaching Log #2 (IG; during the pilot unit)
- Questionnaire (IG; after completing the pilot unit)
- Focus Group Interview (IG; after completing the pilot unit)
Each data collection method and the associated methods of data analysis will be described in turn. Table 3 presents a matrix aligning each data source with the research questions.

Table 3

*Data Collection Matrix*

<table>
<thead>
<tr>
<th>Research Question</th>
<th>3. Testing Phase</th>
<th>4. Initial Reflection Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) What characteristics of the Curriculum Support materials and related professional development promoted teachers’ understanding of teaching as a design activity?</td>
<td>- IG Planning &amp; Teaching Log #1 (prior to individual interview)</td>
<td>- IG Questionnaire (after pilot unit)</td>
</tr>
<tr>
<td></td>
<td>- IG Individual Interview (prior to pilot unit)</td>
<td>- IG Focus Group Interview (after pilot unit)</td>
</tr>
<tr>
<td></td>
<td>- IG Planning &amp; Teaching Log #2 (during pilot unit)</td>
<td></td>
</tr>
<tr>
<td>2) What characteristics of the Curriculum Support Materials and related professional development supported teachers in engaging in teaching as design?</td>
<td>- IG Planning &amp; Teaching Log #1 (prior to individual interview)</td>
<td>- IG Questionnaire (after pilot unit)</td>
</tr>
<tr>
<td></td>
<td>- IG Individual Interview (prior to pilot unit)</td>
<td>- IG Focus Group Interview (after pilot unit)</td>
</tr>
<tr>
<td></td>
<td>- IG Planning &amp; Teaching Log #2 (during pilot unit)</td>
<td></td>
</tr>
</tbody>
</table>

**Planning and Teaching Log #1 and Individual Interview.**

During the study, each IG teacher completed two logs recording their mathematics planning and teaching actions over a 10-day period (see Appendix F). The first log was intended to engage the teachers in self-reflection before the individual interview by asking them to stop and think about what they actually do when planning and teaching mathematics each day. The log prompts asked the teachers to describe their planning and preparation at the unit level as well as for their daily lessons, including the resources they used and how they used them.
After they had completed this log, I interviewed each IG member individually (see Appendix G for the interview protocol). My goal for these one-hour interviews was to understand as much as possible about the IG members’ teaching backgrounds and mind sets to assist me in understanding and interpreting their subsequent experiences with the pilot unit and their evaluations of the CSM. These interviews were designed as a modified version of what Seidman (2006) referred to as a “focused life history,” and may be thought of as a focused teaching history.

My intent was to increase the IG members’ awareness of their mathematics teaching behaviors through their experiences with the first log and the individual interview, preparing them to reflect on their use of the CSM during the pilot. In addition, I hoped to catch a glimpse of the extent to which each of the IG teachers’ were already engaging in teaching as design.

**Planning and Teaching Log #2.**

The IG teachers kept a second planning and teaching log (see Appendix F) recording their mathematics planning and teaching actions during the 10-day pilot unit. The prompts of this second log were the same as those for the first log, with the addition of a reminder to provide specific details about their use of any resources from the CSM web site. The purpose of the second log was for the IG teachers to capture their specific uses of the CSM during the pilot unit, creating a document to which they could refer, if needed, when completing the post-unit questionnaire and participating in the IG Focus Group Interview described in the following section. The analysis and coding of the teachers’ comments from the second log is described in the following section.
**Questionnaire and Implementation Group Focus Group Interview.**

After teaching the pilot unit, each IG member completed a questionnaire (see Appendix H) regarding their experiences during the unit, responding to prompts similar to those used in Planning and Teaching Log #2. The second log and the questionnaire were designed to complement each other, with the log capturing the teachers’ thoughts and actions “in the heat of battle” and the questionnaire generating a reflective narrative of those thoughts and actions after the fact. The questionnaire was also intended to prepare the IG members for their subsequent focus group interview by asking them to write and reflect beforehand, and provided a means for capturing individual perspectives that might be lost in the group interview setting.

The IG Focus Group Interview was the primary data source for evaluating the potential of the CSM for promoting teaching as design. I facilitated this 90-minute interview in collaboration with the DG members, asking the IG to share their experiences with the pilot unit, including their perceptions of the strengths and weaknesses of the CSM, the potential of the CSM for promoting teaching as design, and needed revisions and improvements.

The development of the focus group interview protocol (see Appendix I) was guided by the recommendations of Russ-Eft and Preskill (2009) and Cheng (2007) for crafting clear, simple, and open-ended questions. The goal of this focus group interview was “to get at what people really think about an issue or issues [the CSM] in a social context where the participants can hear the views of others and consider their own views accordingly” (Fraenkel & Wallen, 2009, p. 452), because, as Rossman and Rallis (2003) noted, “people often need to listen to others’ opinions and understandings to clarify their own” (p. 193). The characteristics of focus group interviews are consistent with the collaborative nature of design research, making it an appropriate method of data collection for this study.
I made an audio recording of the IG Focus Group Interview and transcribed the recording. This transcript was then shared and discussed with the DG members during the subsequent DG Focus Group Interview (see Additional Data Sources, below) as my first step in reflecting on this data. I later analyzed the IG members’ comments from the second log, the questionnaire, and the interview transcript to identify comments that had similar meanings, grouping and labeling them with a descriptive code. These codes were categorized into themes, corresponding to the seven sections of the CSM web site, which will be used to frame the discussion of the study’s findings in Chapter 7.

**Additional Data Sources.**

In addition to these data sources that were directly aligned with the study’s research questions, I collected data from three other sources to inform the reporting of this study: my research journal; the documentation of the work of the DG; and the DG Focus Group Interview. While these additional data sources were not directly aligned with the research questions, the information that they provided was helpful for reporting the “detailed design history” (Collins et al., 2004, p. 34) of this study.

**Research Journal and Design Group Documentation.**

As noted previously in this chapter, I maintained a research journal throughout this study, intended to increase my reflexivity through consistent reflection on my role as a practitioner-researcher. Entries included plans and reflections for the scheduled activities of the research team, as well as spontaneous troubleshooting and reflections regarding other issues as they arose. I also documented the work of the DG in multiple ways, including: field notes; email exchanges; audio recordings of group meetings; entry and exit slips from group meetings; and comments posted to our online workspace. Together, these served as the central data sources for the
Analysis and Development phases and were essential for providing the “thick description” (Gertz, 1983, as quoted in Rossman & Rallis, 2003, p. 46) of the design research process contained in Chapters 2 and 5 of this dissertation.

**Design Group Focus Group Interview.**

The final data source for this study was the DG Focus Group Interview, conducted one week after the IG Focus Group Interview. I facilitated this 90-minute interview of the DG members using a similar protocol (see Appendix J) to that of first focus group interview, concentrating on their perceptions of the overall success of the study and their recommendations for revising the CSM. This second focus group interview was both the last step in the data collection process and the first step in the Analysis and Reflection phase. I began by revisiting the IG Focus Group Interview (which they had helped to facilitate), asking them to share their recollections and identify important themes from the IG members’ comments, referring to the transcript of the IG interview as needed. It was helpful for me to “hear what they’d heard” as they shared their varying perspectives on the first interview. I concluded the interview by asking them to look back over the four-month study, comment on their sense of the effectiveness of the process, and make suggestions for improving future design work. They also shared their ideas regarding the possibility of expanding the CSM for district-wide implementation.

I employed the same data analysis process for this interview as I did for the IG Focus Group Interview: recording, transcribing, analyzing, coding, and checking for emerging themes. The outcomes of this interview are discussed in Chapters 7 and 8.

**Addressing Trustworthiness**

All research must endure questions of validity and reliability and, as discussed in Chapter 2, design research studies are often subject to intense scrutiny on these issues because of the
method’s inherent differences from traditional scientific research. In this dissertation I have proposed an adaptation of Reeves’ model of design research (see Figure 13) aimed at increasing the trustworthiness of the findings of design research through the standardization of the research questions and reporting techniques employed in these studies. In Chapter 1, I demonstrated that the research questions of this study were appropriate for a design research approach, and I have also shown that this dissertation is structured according to Collins et al.’s (2004) recommendations for reporting the findings of design research (see Chapter 4). This section presents several additional features that I have incorporated into the design of this study to enhance its trustworthiness.

Rossman and Rallis (2003) identified three standards for practice that can be helpful in “judging the integrity and value of qualitative studies” (p. 69): truth value, rigor, and usefulness. The authors also offered specific strategies for promoting these standards. Truth value can be increased by gathering data “over a period of time… sharing your interpretations of the emergent findings with participants… [and] designing the study as participatory or action research from beginning to end” (p. 66). To increase the truth value of this study, data was collected from the IG teachers over a period of six weeks. The emerging findings from the questionnaire and IG Focus Group Interview were shared with the DG members during the second focus group interview and the overall findings of the study were submitted to the entire research team to ensure accuracy. In addition, the structure of this design research study was inherently participatory.

Rigor can be enhanced by “triangulation [of] multiple sources of data, multiple points in time, or a variety of methods” (Rossman & Rallis, 2003, p. 69), “prolonged engagement… with participants… [to] ensure that you have more than a snapshot view of the phenomenon” (p. 69),
and “using the community of practice [by] engaging in critical and sustained discussion with valued colleagues in a setting of sufficient trust…” (p. 69). The rigor of this study was increased through the use of multiple sources of data as described in this chapter. My collaboration with the DG over the course of this four-month study was clearly a prolonged engagement that provided me with regular opportunities to engage in critical discussions with the DG members regarding our design decisions.

Usefulness can be promoted by providing “complete descriptions of your theoretical and methodological orientation and the process… [and by including] thick, rich description” (Rossman & Rallis, 2003, p. 68) of a study’s context and findings. Chapters 2, 3, and 4 offered complete descriptions of this study’s theoretical foundation and research method, increasing the usefulness of this study’s findings by making it easier for potential users to evaluate my research design. This chapter has described the context and structure of the study; Chapter 7 provides a detailed description of the findings.
Chapter 7: Findings

This chapter describes the outcomes of the Testing and Initial Reflection phases of the study. To address the study’s two research questions, each of the seven sections of the CSM web site are evaluated using data collected from the Implementation Group through the second Planning and Teaching Log, the IG Questionnaire, and the IG Focus Group Interview. Relevant data from the DG Focus Interview are included as well.

The purpose of this study was to explore the potential of CSM for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design. The study was guided by two research questions:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

These questions were addressed using evidence collected from the four Implementation Group teachers through multiple data sources that were intended to capture their experiences with the CSM during the pilot unit. The seven sections of the CSM website were evaluated with respect to the research questions. The findings of this study will inform the revision of the piloted CSM, guide the design of future CSM, and lay the groundwork for future study of their effectiveness.

As presented in Chapter 5, the first three sections of the CSM web site (Home, Teaching as Design, and Getting Started) were intended to promote teachers’ understanding of teaching as a design activity, while the remaining four sections (The Unit Checklist, Resources by Topic, Introducing Multiplication and Division, and Should Be Able To) of the web site were intended to support teachers in engaging in teaching as a design activity. The potential of each of these
sections for promoting teachers’ understanding of teaching as design or for supporting teachers in engaging in teaching as a design activity were evaluated using evidence from Planning and Teaching Log #2 (PTL2), the IG Questionnaire (IGQ), and the IG Focus Group Interview (IGFI), and the DG Focus Interview (DGFI), focusing on the intended purposes of each section. Note that, since the CSM web site has been described fully in Chapter 5, this chapter will provide only brief details of each section; complete screen captures of the CSM web site can be found in Appendix D.

**CSM Web Site Section 1: Home**

*purposes: understanding teaching as design; mathematics pedagogical content beliefs*

The Home section (see Figures 14 and 15) was intended to set the stage for the CSM web site, using Mission and Vision statements and quotes from NCTM (2000) and Shulman (1990) to introduce the concept of teaching as design and establish our view of teachers as decision makers who use, rather than implement, curriculum. Data regarding this brief section were limited; none of the IG members mentioned it specifically in the PTL2 or the IGQ, but the Home section was discussed during the IGFI. The IG responded favorably to the content of this section, indicating that it was simple and welcoming. One IG member commented:

I think the vision is nice, because people think that programs are miracle workers, and you won’t find many counties with supervisors as educated to trust their staff to say that, ‘We believe our teachers are decision makers who use curriculum materials as tools.’

A second IG member noted that “a lot of teachers don’t have the confidence to do that [use curriculum materials as tools].”
CSM Web Site Section 2: Teaching as Design

Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs

The second section of the CSM web site, Teaching as Design (see Figures 16 and 17), was intended to clarify how teaching is a design activity, through the use of an introductory quote by Wiggins and McTighe (2005) and a list of examples of tasks common to design professions (Stepanek et al., 2011). The purpose of the Our Approach subsection was to assert that teaching as design is “just good teaching” and that it would not require teachers to make drastic changes to their current instructional practices. As with the Home section of the web site, data regarding this brief section were limited; none of the IG members mentioned it specifically in PTL2 or the IGQ, but this section was discussed during the IGFI. The IG responded favorably to the content of this section as well. The only suggestion for improvement was that the sentence “Teachers are designers.” at the beginning of the Wiggins and McTighe quote should be emphasized using a bold or colored font, because “many [teachers] don’t see themselves that way – make it attention grabbing.” The same IG member also recommended that:

When you’re teaching people [about teaching as design], give them a chance to reflect on situations where they have designed something in the past, so they can see that is a behavior that can be duplicated and replicated in this other scenario [teaching mathematics].

A second IG member observed that:

I think that you do it [teach as design] in science and social studies without even realizing it: ‘Oh yeah, I don’t use a textbook for everything; I go and pull from it when I need to.’

During IGFI, the DG members agreed with these suggestions, noting that helping teachers compare their mathematics planning and teaching behaviors to their behaviors when planning
and teaching other subjects might be a useful strategy for introducing the idea of teaching as design. No IG members expressed concerns about this section of the CSM web site.

**CSM Web Site Section 3: Getting Started**

*Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs; Providing Multiple Points of Access; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment*

The Getting Started section contained the majority of our content explaining teaching as design, organized around the five essential features of teaching as design that were described in Chapter 2. The purposes of this section of the CSM web site expanded on those of the first two sections to include providing multiple points of access, supporting customization, linking goals to materials, and emphasizing assessment. Data regarding the Getting Started section were more plentiful than for the first two sections. In the PLT2, three of the four IG members specifically mentioned using this section during the pilot unit and all four members of the IG identified this section as one of the most useful features of the CSM web site on the IGFI exit slip.

In terms of providing multiple points of access, the Getting Started section was intended to provide brief, clear explanations of each essential feature accompanied by links to supplemental resources, allowing users flexibility in exploring the content. The IG indicated that this goal was realized and all four members accessed the content uniquely. One IG member “read all the articles and really enjoyed them,” while a second member “read all the main headings, but didn’t have the time to look at [the supplemental resources],” and a third IG member described “clicking on a couple” of the links to explore the supplemental resources. The fourth member, who had worked previously with *Understanding by Design* (Wiggins and McTighe, 2005) and found it confusing, noted that this section of the site made teaching as
design accessible for teachers, commenting that she “really liked the fact that it takes you through [teaching as design] step by step.”

The Getting Started section was also intended to support customization and help teachers to link instructional goals to curriculum materials, primarily by introducing these concepts through the information related to Essential Feature #1: Planning Backward from Learning Goals, Essential Feature #3: Reviewing Available Resources, and Essential Feature #4: Matching Instruction to Goals and Assessments. Data specific to these two purposes were limited, although one IG member commented specifically that this section of the website provided “many choices… you have the option of [doing] what it is that you feel is best for you as a teacher, for the children that you’re teaching.”

The final purpose of the Getting Started section was to emphasize the importance of assessment through the information related to Essential Feature #2: Selecting Assessments Before Lessons and Essential Feature #5: Using Ongoing Formative assessment to Guide Instruction. Three of the four IG members mentioned using assessment resources from this section in the PLT2 and two of them identified these assessment resources as one of the most useful features of the CSM web site on the IGFI exit slip. One IG member printed out two of the assessment resources “to keep close when planning and reflecting to help me as a reminder of what my goals were for my students and myself.” Another noted that “the biggest change in my teaching was the assessment piece…. I got together all of my assessments up front and I didn’t need to try to find something after we had started the unit.”

Overall, the IG responded positively to the Getting Started section of the website, noting that it was “accessible” and read like a “friendly, professional conversation.” One IG member stated that “the description of teaching as design was very helpful in getting me to think about
process, analysis, structure, and planning/observation…. The [essential features of teaching as design] can be revolutionary in changing how teachers plan.” Another IG member asserted that this section of the CSM web site “really does give you the bottom line of what backwards design is,” while a third member described it as “a great overview for teachers who are new to backward planning and don’t have the confidence to steer away from the adopted curriculum.” The fourth IG member commented that “teachers who are interested in teaching as design would, I think, find this site invaluable.” No IG members expressed concerns about this section of the CSM web site.

CSM Web Site Section 4: The Unit Checklist

_Purposes: Understanding Teaching as Design; Mathematics Pedagogical Content Beliefs; Providing Multiple Points of Access; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment_

As discussed in Chapter 5, the Unit Checklist (see Figure 20) was intended to serve as a bridge between the two goals of the CSM web site by providing a means for teachers to begin engaging in teaching as design that could also enhance their understanding of the concept by modeling what it looks like in practice. Our primary goal was to create a flexible tool that could be used by teachers of all levels of experience and skill. The purposes of the checklist were identical to those for the Getting Started section of the web site, because the checklist may be thought of as a manifestation of the essential features of teaching as design.

Three of the four IG members mentioned using the unit checklist in the PLT2 and two of those members reported referring to the checklist throughout the pilot unit. Three IG members identified the unit checklist as one of the most useful features of the CSM web site on the IGFI exit slip and all members of the DG identified it as the most useful outcome of the overall study
during the Design Group Focus Interview (DGFI) exit slip. The checklist was discussed at length during both focus interviews.

In terms of helping teachers understand teaching as design, one IG member commented that the checklist “seemed to wrap up what I had known and also what I’d read on the web site, which was like a refresher from college classes… I could see this being a professional development [resource] for any content area.” Regarding the development of teachers’ mathematics pedagogical content beliefs, a second IG member noted that “if you’ve taught long enough, you think about that stuff [on the checklist] naturally, but to really put an emphasis on it or to re-confirm it, it’s really good to do that again. …It took me four years of doing everything by the book before I even remotely felt confident enough to think about what I [emphasis added] thought.”

The IG perceived the unit checklist as successfully providing multiple points of access and supporting customization, based on the different ways it was utilized by different members. One IG member stated: “I printed off the checklist and started going down each one of the things in the Before section. …I used it every time I got ready to re-teach or revise a lesson.” Another IG member noted:

I did use the checklist a lot and I felt like it was something that should be laminated and stuck in the front of teachers’ plan books to continue to remind them… it’s a great reminder to keep you thinking and keep you on track and focused on what you need to be doing and where you’re going.

A third IG member “looked at it a lot during the Before,” but then chose not to revisit the checklist during the unit, while the fourth IG member reviewed the checklist and elected not to
use it because she felt that she was already incorporating the checklist items into her regular planning: “I just tucked it away – ‘Oh, I’m doing that.’”

Specific data on linking goals to curriculum materials were limited, although one of the IG members who reported using the checklist throughout the pilot unit stated: “I looked at all of my available resources before I did anything else.”

In terms of emphasizing assessment, the IG members reported multiple instances of the checklist’s impact on their use of assessment. In the IGQ responses for the three IG members who reported using the checklist at the beginning of the pilot unit, one member noted that “the first thing I had to decide was what kind of pre-assessments to do.” The second member reported that she had scanned the web site “to look over the resources I might be able to use as a formative type assessment… [and then] planned the pre-assessment to use [on the first day of the pilot unit].” The third member reported that she had:

Printed the unit checklist… decided what my pre-assessments should show me… chosen some pre-assessments that would give me information on each sub-topic I wanted to assess… decided what pre-assessments to use and when to use them… [and] chosen/developed formative assessments [using] the suggestions from the web site.

In addition, during the IGFI, the IG member who did not use the checklist during the pilot unit commented:

But I did like that assess student learning was in there during and after, because I think that’s the big thing. You need to monitor your kids because you might have to do a different lesson tomorrow or you might have to do a different activity.
Another IG member further commented that the checklist “could really become more of a way of thinking and changing your planning – not just for math. It could really get teachers into thinking about pre-assessment to differentiate for anything.”

Overall, the IG responded very favorably to the unit checklist. As one IG member stated:

I went back to [the unit checklist] over and over and over to keep me on track. It had everything that I needed to think about in one place. I had never seen anything like that before. [In the past] I just had a bunch of stuff written down in a notebook… and [now] there it is, right there, everything right in front of me. I thought it was absolutely wonderful. …I didn’t run off the rails like I usually do.

No IG members expressed concerns about this section of the CSM web site. In addition, the members of the DG were unanimously optimistic about the potential usefulness of the unit checklist, as summed up by this comment from a DG member during the DGFI:

I am glad that the checklist exists and I look forward to using it next year in my planning… Any county could pick up the checklist and adapt it to whatever they’re doing. You [wouldn’t] have to change it that much and it’s stuff that’s going to stay, instead of buzz words that we tend to throw [around] in education. …I think that it will be useful.

**CSM Web Site Section 5: Resources by Topic**

*Purposes: Mathematics Content Knowledge; Mathematics Pedagogical Content Knowledge; Mathematics Pedagogical Content Beliefs; Emphasizing Assessment*

The Resources by Topic section was included to make the CSM web site easier to use by allowing navigation to all of the instructional resources from one page (see Figure 22).

Eventually, this section could be expanded to include links to resources to support other topics, but for the purposes of this study, it linked only to the Introducing Multiplication and Division
resources. As a result, this page was essentially an organizational tool, since its only content related to teaching as design was the first teacher professional development video, Why We Need to Teach the Big Ideas. In providing feedback on the six videos, the IG tended to refer to them collectively, despite the fact that the videos were posted to three separate sections of the CSM web site: Resources by Topic (1 video), Introducing Multiplication and Division (4 videos), and BAT #4 - Determine Unknown Number in Equation (1 video). To facilitate the reporting of my findings, all of the data related to the professional development videos will be presented in the next section, CSM Web Site Section 6: Introducing Multiplication and Division, and no data will be reported for the Resources by Topic section itself. Although this was not my original intent, I do not believe this will affect the overall evaluation of the CSM web site, because all of the intended purposes of the Resources by Topic section were included in the purposes of the Introducing Multiplication and Division section as well.

**CSM Web Site Section 6: Introducing Multiplication and Division**

*Purposes: Mathematics Content Knowledge; Mathematics Pedagogical Content Knowledge; Mathematics Pedagogical Content Beliefs; Multiple Points of Access; Emphasizing Assessment*

As identified in Chapter 2, the first essential feature of teaching as design is planning backward from learning goals. The content related to this feature in the Getting Started section of the site included three questions that teachers should consider when establishing their learning goals (Wiggins & McTighe, 2005):

- What are the big ideas of elementary mathematics that I want to address?
- What do my students need to understand about those big ideas?
- What do they need to know and be able to do?
The Introducing Multiplication and Division section of the CSM web site was composed primarily of professional development videos explaining what students should understand, know, and be able to do when beginning to learn about multiplication and division.

In the PLT2, all four of the IG members reported viewing the videos at the beginning of the unit, three of the four reported viewing the videos again during the unit, and one reported sharing one of the videos with her students. On the IGFI exit slip, three of the four IG members identified the videos as one of the most useful features of the CSM web site. In addition, all members of the DG identified the videos as one of the most useful features of the site on the DGFI exit slip. The videos were discussed at length during the IGFI, during which two of the IG members stated separately that they “loved the videos.”

The primary purpose of the videos was to develop teachers’ mathematics content knowledge and mathematics pedagogical content knowledge. The IG responded favorably to the videos’ potential for developing teacher knowledge. During the IGFI, one IG member stated:

I never understood the reasons behind multiplication and division before and the whole ‘equal groups’ thing. I knew about equal sharing for division, but ‘equal groups’ was new to me, I’d never been taught like that before. I loved the videos you made for us. …The videos taught me and helped explain and give examples better than I could have found the words for.

A second IG member followed up on this comment, noting that “there are so many [teachers] that are going to feel the same way.” This member further stated that “the videos were super helpful to give [me] confidence in knowing how to teach the number lines, because that wasn’t something that I felt that I would excel at.”
The videos were also intended to impact teachers’ mathematics pedagogical content beliefs – in particular, the first video, Why We Need to Teach the Big Ideas. Data related directly to the videos were limited regarding this purpose, however one IG member identified the “explanation of the big idea” as one of the most useful features of the CSM web site on the IGFI exit slip, while a second IG member noted during the IGFI that she “liked the idea that you started out with the big idea and that they should understand that, and then they should know, and then they should be able to do. I liked the way it was set up. …The big idea is always hard for me.”

In addition, the videos were intended to provide multiple points of access for teachers. The IG’s comments during the IGFI related to this purpose primarily addressed the organization and length of the videos and all four members agreed that “having them separated into these short [segments] is good.” One IG member noted that the videos “are just a few minutes long,” and a second IG member stated, “I think they’re a good length. If you make them shorter, you’re going to have to cut out some information that we really need. …I just like the way it was set up.” Another IG member pointed out that use of several short videos allowed her to access specific content as needed:

I tried to watch each video that pertained to what I was teaching the next week or the next day – depending on my limits of time – right before I was to teach that type of multiplication or division problem. …‘Let me watch this video really quick the night before just to get me in the right frame of mind.’

The final purpose of the videos was emphasizing assessment. The videos attempted to highlight the value of assessment for accurately gauging student understanding. For example, the video Why We Need to Teach the Big Ideas described a common student misunderstanding
regarding the meaning of multiplication as discovered through the use of a nontraditional assessment tool, while the video Be Able To provided specific recommendations for assessing the four BAT associated with beginning to learn about multiplication and division. One IG member noted on the IGQ that “I knew the types of questions I wanted to end the unit with after watching the online videos.” A second IG member stated, “I decided that having students make their own word problems would show me their ability to interpret products and solve word problems. I had students do this on various occasions [throughout the unit],” which was a specific strategy described in the Be Able To video. Also in the IGQ, a third member described having “re-watched the videos… [to make] sure that I understood all of this information” before developing her assessments for the pilot unit.

Overall, the IG responded favorably to the videos, as captured by one IG member who described the videos simply as “a great teaching tool.” No IG members expressed concerns about this section of the CSM web site. In addition, all of the DG members identified the videos as one of the most useful outcomes of the study, with one DG member noting that, regardless of our division’s future use of the CSM web site, “the videos could be an excellent stand-alone professional development resource that teachers will find very helpful.”

**CSM Web Site Section 7: Should Be Able To**

*Purpose*: Multiple Points of Access; Employing a “Resource-centric” Design; Supporting Customization; Linking Goals to Materials; Emphasizing Assessment

The final section of the CSM web site consisted of four separate web pages, each devoted to one of the things students should Be Able To (BAT) do that were identified in the Introducing Multiplication and Division section. The primary purpose of these pages was to address M. W. Brown’s recommendation for employing a resource-centric approach to the design of curriculum materials while providing multiple points of access to support teachers in linking their learning
goals to curriculum materials and supporting customization. We began each BAT page by identifying related state and national standards (see Figure 23) so that teachers could see how a single BAT develops across grade levels. The remainder of each page identified related assessment and teaching resources, the majority of which came from our school division’s recently-adopted K-5 mathematics program, Houghton-Mifflin’s *Math Expressions*.

In the PLT2, all four IG members reported having consulted the BAT section of the web site before the pilot unit, as well as having incorporated resources from this section into their instruction during the pilot unit. On the IGFI exit slip, two IG members identified the redesign of the BAT section as being the most important improvement needed to increase the usefulness of the CSM web site. This section was discussed at length during both focus interviews and, during the DGFI, the DG identified addressing the IG’s concerns with this section as the top priority for future revisions of the CSM web site.

Regarding the first purpose of the BAT section, providing multiple points of access, the IG provided clear feedback indicating that we were not successful in doing so. While the four IG members reported having worked with these resources in different ways, only one of them reported having been able to navigate the resources smoothly to incorporate them into her instruction during the pilot unit. On the IGFI exit slip, even this IG member stated that she “found the layout of the web site to be very easy to navigate and understand, but I can see how some teachers may be intimidated by it.” The consensus opinion of the IG can be summed up by the exit slip comment of one member, who noted: “I am a very tech-savvy person but I was really overwhelmed [by the BAT section].”

In terms of the next three purposes of this section of the web site – employing a resource-centric design, supporting customization, and linking goals to curriculum materials – the IG
found the BAT pages to be similarly problematic. On the IGFI exit slip, one IG member noted that the BAT “resources can be overwhelming.” During the IGFI, another IG member simply stated “there’s a lot of stuff [in the BAT section].” This member further noted on the IGQ that “it took a lot of time to review and manipulate” and indicated that she would have needed significantly more time to review the resources in order to have used them more effectively.

Another IG member summarized her concerns as follows:

> Even though everything is separated nicely, being in electronic format only allows the user to see one [resource] at a time. I need to have everything spread out in front of me, so I had to print things out. …It drove me crazy when I could only see one screen at a time. …Clicking from page to page and remembering what you’ve [already] seen and what you haven’t was hard. …I’ll see resources on one page and then I’ll click on another skill [BAT] and see the same resources or activities… because most of these activities teach three or four of those things.

Overall, the IG clearly expressed multiple concerns about the organization and usefulness of this section of the CSM web site, indicating that we were unsuccessful in meeting our intended purposes of providing multiple points of access, employing a resource-centric design, and supporting customization.

The final purpose of the BAT section was emphasizing assessment. Data related to this purpose were limited. In the PLT2, three of the four IG members reported having used or adapted assessments provided in this section of the web site during the pilot unit, while one IG member identified the assessments provided in the BAT section as one of the most useful features of the CSM web site.
Summarizing the Data

This study evaluated six of the seven sections of the CSM web site with respect to the nine purposes identified in Chapter 5, using data collected from multiple sources during the Testing and Initial Reflection phases of the study. Three of the CSM web site sections (Home, Teaching as Design, and Getting Started) corresponded to the study’s first research question:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

A total of ten intended purposes were evaluated for these three web site sections. Three other sections of the CSM web site (The Unit Checklist, Introducing Multiplication and Division, and Should Be Able To; as noted previously in this chapter, the Resources by Topic section was not evaluated) corresponded to the study’s second research question:

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

Sixteen intended purposes were evaluated for these three web site sections. Table 4 summarizes the findings of the evaluation of the 26 overall intended purposes.

Of the ten intended purposes of the web site sections corresponding to Research Question #1, eight of the purposes were met and there were insufficient data available to evaluate two of the purposes. Of the 16 intended purposes of the web site sections corresponding to Research Question #2, eight of the purposes were met, four were not met, and there were insufficient data available to evaluate four of the purposes. All four of the intended purposes that were not met were associated with the BAT section of the CSM web site.
Table 4
Evaluating the CSM Web Site

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Research Question #1: Understanding Teaching as Design</th>
<th>Research Question #2: Engaging in Teaching as Design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CSM Web Site Section</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Home</td>
<td>Teaching as Design</td>
</tr>
<tr>
<td>Understanding Teaching as Design</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Mathematics Content Knowledge</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Mathematics Pedagogical Content Knowledge</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Mathematics Pedagogical Content Beliefs</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Providing Multiple Points of Access</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Employing a “Resource-centric” Design</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Supporting Customization</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Linking Goals to Curriculum Materials</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Emphasizing Assessment</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Note. N indicates this purpose was met; X indicates this purpose was not met.
Additional Findings

Beyond the findings that have already been shared in this chapter, two closely related themes emerged during my analysis of the data from the PLT2, the IGQ, and the IGFI that may be helpful in understanding the experiences of the IG during the pilot study: 1) the impact of the study’s time frame; and 2) the impact of our school division adopting a new K-5 mathematics program.

Impact of the Study’s Time Frame

This study was conducted over the four month period from the beginning of February through the first week of June, 2011. The Analysis and Development phases lasted approximately seven weeks each and the Testing and Initial Reflection phases lasted approximately two weeks each. Since my research team was composed entirely of practicing educators, we were necessarily constrained by our school division’s academic year, which ended on June 10th. My original time line for the study called for the Development phase to be completed by May 1st in order to allow the IG to explore the CSM web site for approximately two weeks before beginning the pilot unit in the middle of May while ensuring sufficient time for the focus group interviews to be conducted before the end of the school year. However, the DG’s work during the Analysis and Development phases took longer than I had anticipated, with the unfortunate result that the IG members had only two days to explore the web site prior to beginning the pilot unit.

During the IGFI, three of the four IG members mentioned that this short time frame had a limiting effect on their use of the resources on the CSM web site. One IG member commented: “I didn’t feel like I had thought [the pilot unit] out as well as I would have normally, because [of the short preparation time provided]… so, I didn’t feel like I got a really great start on it.” A
second IG member agreed: “I felt the same way… like I was planning a day at a time.” The first IG member further noted on the IGQ: “I didn’t feel like I had a lot of time to look over new resources. … I just didn’t have the time that I would have liked to research newer and/or different ideas.” The second IG member suggested during the IGFI that the CSM web site resources “wouldn’t have been too much if we didn’t have such a short turnaround time.”

**Impact of the New K-5 Mathematics Program**

As mentioned briefly in Chapter 5, during the middle of the Development phase of the study our school district adopted a new elementary mathematics curriculum program to be put in place at the beginning of the next academic year. Consequently, the DG was faced with a challenging decision between organizing the BAT pages around the existing program – which our teachers had been using for eleven years – or around the new program. We elected to focus on the new program so that the BAT resources could potentially be used by our school division in the future without having to start the resource development process over from the beginning. We hoped that emphasizing resources from the new program would not present a significant obstacle to the IG’s use of the BAT, since two of the IG members had played extensive roles in the division’s textbook review process. However, this does not seem to have been the case.

Three of the four IG members reported in the PLT2 or on the IGQ that during the pilot unit they had opted to use an instructional resource that they had used previously over a similar resource from the new program. As one IG member described her decision: “I would have preferred to use more resources from the web site, but tended to shy away from some lessons because I knew of something similar that I had used before and it was successful.” While there is nothing inherently problematic about these decisions – they are, in fact, clearly in the spirit of teaching as design – it is telling that such a strong group of teachers felt that they needed
additional time to experiment with new resources before using them with their students. As one IG member noted on the IGQ:

I think that it takes years of practice and exposure to different types of learners to see for yourself which strategies and resources work best with different students. …I like the idea of teaching from the program [for] the first year so that you can make improvements in future years.

These issues of providing teachers sufficient time to explore the CSM web site and anticipating their needs in adapting to the new mathematics program resonated with the DG during the DGFI, and they identified them as two important factors to consider during future revisions of the CSM web site.

**Summary**

This chapter described the findings of the study, using data from the second Planning and Teaching Log, the Implementation Group Questionnaire, the Implementation Group Focus Interview, and the Design Group Focus Interview to evaluate the sections of the CSM web site with respect to its intended purposes. Two additional themes that emerged during the data analysis, the impact of the study’s time line and the impact of the adoption of a new K-5 mathematics program, were also discussed in terms of their impact on the experiences of the Implementation Group during the pilot unit.
Chapter 8: Conclusions

This chapter presents the lessons learned during the study regarding the potential of the CSM web site for promoting elementary mathematics teachers’ understanding of teaching as design and supporting teachers in engaging in teaching as design. Recommendations for the improvement of the web site are presented and the direction of future development efforts and further study are discussed.

This study explored the potential of Curriculum Support Materials (CSM) for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design, employing a design research approach to trace the design, development, and evaluation of the CSM web site. The intent was to develop a resource that could introduce the concept of teaching as design and then serve as an intermediary between teachers and curriculum materials to develop teachers’ understanding of the purposes and possible uses of the CSM materials (M. W. Brown, 2009). Because this was an exploratory study, it did not attempt to obtain conclusive evidence of the CSM’s effectiveness, but instead attempted to learn about its potential (McKenney, 2001) for promoting teaching as design. As Kelly (2006) noted, “design research may be seen as a stage-appropriate response in a multi-stage program of research” (p.114) involving the generation, rather than the testing, of hypotheses and the development of prototypes in a “context of discovery” (p. 114) that can guide further testing and implementation. The findings of this study will inform the revision of the piloted CSM web site, guide future development, and lay the groundwork for future study of its effectiveness. This chapter presents the lessons learned during the study with regard to the study’s research questions, along with recommendations for improving the web site and suggestions for the direction of future development efforts and further study.
Lessons Learned

The study was guided by two research questions:

1) What characteristics of the CSM promoted teachers’ understanding of teaching as a design activity?

2) What characteristics of the CSM supported teachers in engaging in teaching as design?

With regard to the first research question, the data (see Chapter 7; see also Table 4) provided by the Implementation Group (IG) indicated that the CSM web site has strong potential for promoting teachers’ understanding of teaching as design. Eight of the ten intended purposes of the Home, Teaching as Design, and Getting Started sections of the web site were met, although there was insufficient data available to evaluate the goals of supporting customization and linking goals to curriculum materials for the Getting Started section. The IG members indicated that these first three pages of the CSM web site were welcoming, accessible, clearly organized, and easy to understand. In particular, the IG indicated that the Getting Started section was well-organized, with the main content regarding the five essential features of teaching as design providing sufficient background information to allow users to understand teaching as design, and the supplemental resources allowing teachers to explore these ideas further if desired. The IG members did not express any concerns about these sections of the CSM web site and the only suggested revision was to place a stronger visual emphasis on the statement “teachers are designers” at the beginning of the Wiggins and McTighe (2005) quote in the Teaching as Design section, as mentioned in Chapter 7. The statement of one IG member that the Getting Started section “really does give you the bottom line of what backwards design is” was indicative of the IG’s collective reaction to the potential of the CSM web site for promoting teachers’
understanding of teaching as design. During the Design Group Focus Interview (DGFI), the consensus of the Design Group (DG) was that these three sections were ready to be tested on a larger scale in their current form.

The data from the IG regarding the second research question raised doubts about the potential of the CSM web site for supporting teachers in engaging in teaching as design. Of the 16 intended purposes of the Unit Checklist, Introducing Multiplication and Division (IMD), and Should Be Able To (BAT) sections of the web site, eight were met, four were not met, and there was insufficient data available to evaluate the remaining four purposes. In particular, the IG expressed concerns about the BAT section of the web site: Three of the four intended purposes of this section were not met and there was insufficient data available to evaluate its fourth purpose. The IG’s primary concern regarding this section was that it was overwhelming because the extensive resources were difficult to navigate and review. The data from the IG was much more favorable for the other two sections of the web site corresponding to this research question, indicating that eight of the twelve intended purposes of the Unit Checklist and IMD sections were met, although there was insufficient data to evaluate the remaining four purposes of these sections. In addition, the IG identified the Unit Checklist and the professional development videos (the primary component of the IMD section) as the two most useful features of the CSM web site. The contrast between the IG’s reaction to the BAT section and the rest of the CSM web site was captured by a comment from one IG member on the IGFI exit slip, who noted that “it would be really nice to use [the CSM web site], except for the resources [on the BAT] pages.” The IG expressed that, while teachers were likely to respond favorably to the content of the earlier sections of the web site, the problems with the BAT were significant enough to cause some teachers to react negatively to the site as a whole – and perhaps to the idea of teaching as
design in general. As one IG member asserted on the IGFI exit slip, when attempting to promote teaching as design on a larger scale, it will be important “to roll it out so that teachers are enthused and not overwhelmed.” The data indicate that, while the Unit Checklist and IMD sections have the potential to be useful tools for teachers, collectively these three sections of the CSM web site have limited potential for supporting teachers in engaging in teaching as design.

To summarize, the DG identified two lessons learned from the data provided by the IG:

1) Together, the Home, Teaching as Design, and Getting Started sections of the CSM web site have strong potential for promoting teachers' understanding of teaching as design.

2) Together, the Unit Checklist, IMD, and BAT sections of the CSM web site have limited potential for supporting teachers in engaging in teaching as design, although the Unit Checklist and professional development videos are potentially useful tools for teachers.

An important insight into the limitations of the CSM web site for supporting teachers in engaging in teaching as design can be gained by considering the data regarding its intended purposes of employing a resource-centric design, supporting customization, and linking goals to curriculum materials. This study evaluated a total of seven data points for these three purposes over three separate sections of web site; of these, three of the intended purposes were not met and there was insufficient data available to evaluate the other four purposes. These results stand in sharp contrast to the results for the other intended purposes of the web site; the study evaluated a total of 19 data points for the other purposes over all six sections of the web site and the data indicated that 16 of those intended purposes were met and there was insufficient data available to evaluate two of those purposes. The sole purpose of these 19 that was not met was
providing multiple points of access in the BAT section. Taken together, these findings show how the CSM web site was not well-suited to helping put their understanding of teaching into practice. As one DG member stated during the DGFI, after using the web site to help them understand teaching as design, “people are going to look at it and say, ‘Now what do I do?’” The DG members agreed with my follow-up observation that “what we may be learning here is that a web site is not enough to help teachers get started with teaching as design.”

The idea that a web site alone may not be sufficient for helping teachers begin to engage in design was also noted by the IG members, who agreed with the suggestion of one IG member during the IGFI that learning to teach as design might need to be part of an ongoing learning experience where teachers work together in small groups to develop assessments and plan instruction gradually, “because this idea is going to be a brand new thing for many, many people.” As another IG member observed, learning to begin teaching as design “is a lot to ask someone to do on their own.”

The significance of these lessons learned was discussed at length during the DGFI, resulting in suggestions for re-envisioning our approach to supporting teachers in engaging in teaching as design and redesigning the types of resources included in the final section of the CSM web site. These suggestions will be discussed in the following section.

Looking Forward

Based on my discussions with the DG regarding the study’s findings, I believe that the CSM web site has the potential to help resolve the conflict that my school division’s elementary mathematics teachers have experienced between our adopted curriculum program and the state standards, which served as the catalyst for this study (see Chapter 1). The web site can help teachers reconsider their relationship to the curriculum program, helping them begin to view
themselves as decision makers and textbooks as tools by promoting their understanding of teaching as a design activity. In this way, teachers may better understand the state standards as goals and our curriculum program as one tool (albeit the primary one) for them to use to reach those goals. In order for the CSM web site to support the shift in behavior that will be required for teachers to engage in teaching as design on a regular basis, however, it should be incorporated into an ongoing professional development experience among small teams of teachers. While our hope was that the web site could serve as a stand-alone resource, the IG’s suggestion that it could be more effective if used by teachers as part of an ongoing, shared learning experience is supported by Learning Forward’s standard for Professional Learning Communities: “Professional learning that increases educator effectiveness and results for all students occurs within learning communities committed to continuous improvement, collective responsibility, and goal alignment” (Learning Forward, 2011).

In addition to incorporating the CSM web site into an ongoing professional development experience, I believe the first step in revising the web site should be to shift the focus of our resources from the lesson level to the unit level. The fundamental problem with the BAT section of the web site was that it contained an overwhelming number of resources that were difficult to navigate and review. Even if we could successfully resolve these organizational issues, I am no longer convinced that providing specific lessons and activities was an appropriate decision. During my discussions of the data with the DG members, they shared concerns about the potential misuse of this section, worrying that teachers may feel a need to try to use every resource we had provided – that, by including a resource on the site, we were in effect telling teachers to use it. As a result, this section could unintentionally hinder teachers from engaging in teaching as design if it were misinterpreted as a “to do” list instead of a menu of choices.
I believe that a better course for the future would be to remove the BAT section from the site and replace it with a sample unit related to the big idea of the Introducing Multiplication and Division section. The sample unit could document the experiences of a small team of teachers over the course of two to three weeks as they employed the essential features of teaching as design (supported by the CSM web site) to plan and teach a unit based on the big idea. I envision the sample unit as being extensively annotated, including multiple brief videos of planning sessions modeling the use of the Unit Checklist and the professional development videos, written comments describing teachers’ decisions for selecting lessons and assessments, examples of different instructional approaches aligned to the same unit goals, and samples of student work collected throughout the unit. The IMD section of the web site would be revised so that the links to the current BAT resource pages would be replaced with links to sample assessments for each BAT. My hope is that, by providing a model for putting teaching as design into practice, this new section of the web site would lend itself to being used as part of an ongoing professional development experience, while avoiding the possible misinterpretation of the web site resources as a “to do” list.

This shift toward unit-level resources would build on the strengths of the CSM web site (the Unit Checklist and the professional development videos) and eliminate its primary weakness (the BAT section). It would also provide a more reasonable approach to resource development, because the vast amount of time that would be required to develop annotated lesson-level resources for everything that students should be able to do in elementary mathematics makes the task impractical; though it would also entail extensive time and effort, the development of annotated sample units for the big ideas of elementary mathematics would certainly be more
feasible. In addition, the DG was very supportive of redesigning the web site in this way. As one DG member commented on the DGFI exit slip:

One of the most useful parts of participating in the study was [our] having a say on where to go from here – our decision not to worry about [developing resources for] the smaller parts of planning… [and] instead focusing more on the unit than on the specific lessons and lesson resources.

During the DGFI, the DG also indicated that this shift in the focus of our future resource development efforts could lead to an efficient division of the work load, allowing me as Mathematics Supervisor to concentrate on the creation of the professional development videos related to the big ideas while the teachers on a design team concentrated on the development of the annotated sample units. As one DG member observed, “this would let the supervisor share [his] math content knowledge and the teachers to share their planning and teaching expertise.”

In terms of future study, I believe that a restructured CSM web site could then be evaluated on a larger scale than the pilot test conducted for this exploratory study. I envision using a similar design research approach to trace the design, development and intended purposes of the annotated units and an ongoing professional development program focusing on the CSM web site. The study could then be structured to include multiple teams of testers in different schools, yielding qualitative data that could be used to determine the impact of the web site and related professional development experiences on the design behaviors of the participants.
Reflecting on the Design and Development Process

For a first attempt at employing a design research approach, I was very pleased with the design and development process we used in this study. The process provided me with a wonderful opportunity for in-depth, prolonged collaboration with other practitioners, allowing us to engage in extensive discussions that solidified my understanding of teaching as design and refined my content knowledge related to the big ideas of multiplication and division. The process also produced a product – the CSM web site – that, once it is revised, will become a centerpiece of my future efforts to support elementary mathematics teachers.

In particular, I was struck by the way that the process allowed the members of the DG to “play to their strengths” as they contributed to the design and development of the CSM web site. As our work during the Analysis and Development phases progressed, it became apparent that it wasn’t efficient for all five of us to work together on every task. Instead, I began taking the lead on the development of the web site, the two Elementary Instructional Specialists (EIS) began to concentrate their efforts on researching and critiquing the content of the web site as it evolved, and the two DG teachers became critical evaluators of the usefulness of the overall product. Our work became a cycle of meeting together to discuss and plan, followed by me drafting a section of the web site, the EIS analyzing the content of the draft, and the DG teachers providing detailed feedback and suggestions for revision during our next meeting. In essence, I would listen carefully to the other DG members, create a prototype, share it with the EIS to make sure that we were on the right track, and then bring it back to the DG teachers for further review: “Here’s what I heard you say we should do. Here’s what we’ve come up with so far. What do you think?”
This division of labor was not a conscious decision. Rather, it seemed to occur naturally, with each DG member gravitating toward the aspects of the design and development work that aligned with their daily roles as educators: I regularly created resources for teachers as part of my supervisory responsibilities; the EIS were accustomed to using their considerable knowledge of pedagogy and professional development to evaluate resources and strategies before using them to support teachers; and the DG teachers frequently engaged in professional development, making them well-suited to guide the process toward the creation of a practical and user-friendly resource. The result was a product that was far better than any that I could have created on my own.

This division of labor was also the result of the amount of time each DG member could dedicate to the development process, with me spending more time on the development work than the EIS, and the EIS in turn spending more time than the DG teachers. This was, I believe, an appropriate structure that could be replicated in the future. By establishing a collaborative process that allows practicing educators to fit design research work into their incredibly busy schedules, I hope that we have laid the groundwork for future design research efforts in our school division that will help to bridge the gap between research and practice.

Final Thoughts

As Mathematics Supervisor, I intend to focus my future efforts on helping my teachers understand the big ideas of elementary mathematics and supporting their planning at the unit level, more than at the lesson level. This idea was captured nicely by Morrison (2010) in a recent question and answer segment in the journal *Educational Leadership*, titled “What Do Teachers Need from Curriculum Guides?”:
Less is more. Give teachers a guide, not an “everything bagel.” You might have a sample unit or two, maybe lots of examples, but stick to the big ideas. What we need is not the perfect curriculum guide, but teachers who are able to take the reins and design their own curriculums to meet the needs of the diverse students they teach. (p. 96)

This is the direction I will take as I continue to refine the CSM web site in hopes of developing it into a resource that will help my teachers become designers.
References


Brown, M. W., & Edelson, D. C. (2003). Teaching As Design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice? Evanston, IL: Center for Learning Technologies in Urban Schools, Northwestern University (Available at: [http://www.inquirium.net/people/matt/teaching_as_design-Final.pdf](http://www.inquirium.net/people/matt/teaching_as_design-Final.pdf)).


### Appendix A

Spring 2010 Needs Assessment: Samples of the Previous Curriculum Support Documents

**Grade 3**

**UNIT 1: ROUTINES, REVIEW, AND ASSESSMENT**

<table>
<thead>
<tr>
<th>PACING</th>
<th>CURRICULUM FRAMEWORK EKS&amp;P</th>
<th>EM LEARNING GOALS</th>
<th>GAMES &amp; ASSESSMENTS</th>
<th>RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Nine weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EM TLG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P16-81</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALL LESSONS ARE 1-DAY LESSONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>RECALL UNIT 1 IS AN ASSESSMENT UNIT FOR GRADE 3</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSERT 3 GAME DAYS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-AFTER 1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-AFTER 1.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-AFTER 1.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(also use these game days as additional content days for previous lessons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Investigate and identify the place value for each digit in a six-digit numeral, using base-10 manipulatives (e.g., base-10 blocks).</td>
<td>SECURE GOALS: Know basic addition facts</td>
<td>GAMES TO BE INCLUDED: Addition Top It - Name That Number - Number Top It - Less Than You - Tic-Tac-Toe Addition TIME CARD DECKS: P24 Backward Arrows P26 Clock Concentration P33 Forward Arrows P38 Middle Squeeze P42: Name That Graph P44 Newspaper Times P45 One Thing in Common P66 Vacation Plans MONEY CARD DECKS: P26 Bar Graph Race P28 Beat the Clock P30 Card Sort P31 Coin Concentration P42 Four in Order P44 Higher/Lower P65 Subtraction Coin Top It</td>
<td>FACT SONGS TO BE INCLUDED: MULTIPLICATION SONG FOR 4-FACTS (AUG 2 Six-SEPT 9) MULTIPLICATION SONG FOR 6-FACTS (SEPT 12-SEPT 23)</td>
</tr>
<tr>
<td>3.3</td>
<td>Read six-digit numerals orally. Write six-digit numerals that are stated verbally or written in words.</td>
<td>DEVELOPING/SECURE GOALS: Count by 10s and 100s Apply place value concepts in 4-digit numbers Tell and show times to the nearest minute Count combinations of bills and coins and write the total using dollars-and-cents notation Find equivalent names for numbers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>Describe the meaning of the terms greater than, less than, and equal to. Determine which of two whole numbers between 0 and 9,999 is greater. Determine which of two whole numbers between 0 and 9,999 is less. Compare two whole numbers between 0 and 9,999, using the symbols &gt;, &lt;, or =. Use the inverse relationships between addition/subtraction and multiplication/division to solve related basic fact sentences. For example, 5 + 3 = 8 and 8 – 3 = __; 4 × 3 = 12 and 12 ÷ 4 = __. Write three related basic fact sentences when given one basic fact sentence for addition/subtraction and for multiplication/division. For example, given 3 × 2 = 6, write __ × 3 = 6, 6 ÷ 3 = __, and 6 ÷ __ = 3. Compare the values of two sets of coins or bills, up to $5.00, using the terms greater than, less than, and equal to. Make change from $5.00 or less.</td>
<td>DEVELOPING GOALS: Identify and use number patterns to solve problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# 3rd Grade Mathematics Benchmark Test Blueprint

## Changes for 2009-10
This year's benchmark test content and testing schedule have been altered based on feedback received from teachers and principals over the past year, including maintaining a three-week testing window to allow schools flexibility in scheduling tests, and adjusting the spacing of the tests to allow teachers sufficient time to analyze benchmark data to inform their instruction.

## 2009-10 Benchmark Testing Windows
First Benchmark Test: October 5th – 23rd, 2009  
Second Benchmark Test: November 30th – December 18th, 2009  
Third Benchmark Test: March 8th – 26th, 2010

*PLEASE NOTE: The following Grade 3 SOL will not be assessed on the benchmark tests:*

3.21 & 3.22 (Constructing, reading, and interpreting graphs)  
3.23 (Probability)

Please be sure to assess these standards during the 4th nine-weeks, prior to SOL testing.

## 3rd Grade Math Benchmark Test Blueprint

**First Nine Weeks – 20 Questions**

<table>
<thead>
<tr>
<th>Approx. # Items</th>
<th>Standard of Learning</th>
<th>Notes</th>
<th>Related Released SOL Test Items</th>
<th>Calculators Permitted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3.1 Whole number place value</td>
<td>Moved up to help reinforce rounding during the second nine weeks. May include base-10 block representations.</td>
<td>2007: #2, 9, 10</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>3.4 Inverse relationship between addition &amp; subtraction</td>
<td>+/- fact families; */+ will be assessed on the second benchmark test.</td>
<td>2008: #4</td>
<td>No</td>
</tr>
</tbody>
</table>
| 4               | 3.8 Whole number addition & subtraction | Will include word problems. | 2007: #17, 19  
2008: #16 | No |
| 2               | 3.13 Count & compare money | | 2007: #35  
2008: #26 | No |
| 2               | 3.14a Estimate & measure length | | 2007: #30, 36 | No |
| 2               | 3.15 Telling time | To the nearest five minutes. | 2008: #31 | No |
| 2               | 3.16 Equivalent time periods | | 2008: #36 | No |
| 2               | 3.24 Patterns | Focus on numerical patterns (e.g., skip counting, addition tables, etc.). See VDOE Curriculum Framework. | 2007: #45, 47, 48  
2008: #47, 60 | No |
Appendix B

Spring 2010 Needs Assessment:

Results and Recommendations

Results

This evaluation addressed four key questions:

1. To what extent are K-5 teachers currently utilizing the curriculum support documents to plan their mathematics instruction?
2. What characteristics of the documents do teachers find to be useful?
3. What characteristics of the documents do teachers find to be problematic?
4. What changes to the design and content of the documents do teachers believe would increase the documents' usefulness?

This section summarizes the analysis of the data collected from the online survey, the focus group interview, and the benchmark testing data comparison with respect to each key question.

Key Question 1
To what extent are K-5 teachers currently utilizing the curriculum support documents to plan their mathematics instruction?

Summary of Findings: Many teachers refer to the Curriculum Guide and the Benchmark Test Blueprint in planning their instruction at the beginning of new units, at the beginning of a new nine weeks, and at the beginning of a new academic year. However, teachers do not refer to the Curriculum Guide to find supplemental instructional resources with the same level of consistency. Many teachers currently access the Curriculum Guide and the Benchmark Test Blueprint in both paper and online formats.

Supporting Data: Responses to the relevant survey questions are shown in Tables 6-9:

Table C1
Question 2-4: How often do you refer to the Mathematics Curriculum Guide in planning your instruction?

<table>
<thead>
<tr>
<th></th>
<th>At Least Sometimes</th>
<th>Regularly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>38.1%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Weekly</td>
<td>63.9%</td>
<td>27.8%</td>
</tr>
<tr>
<td>Begin. New Unit</td>
<td>82.5%</td>
<td>58.8%</td>
</tr>
<tr>
<td>Begin. New 9-Weeks</td>
<td>89.7%</td>
<td>58.8%</td>
</tr>
<tr>
<td>Begin. New Year</td>
<td>90.7%</td>
<td>80.4%</td>
</tr>
</tbody>
</table>
Table C2
*Question 2-5: How often do you refer to the Mathematics Curriculum Guide to find supplemental instructional resources?*

<table>
<thead>
<tr>
<th></th>
<th>At Least Sometimes</th>
<th>Regularly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>24.8%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Weekly</td>
<td>41.2%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Begin. New Unit</td>
<td>61.8%</td>
<td>23.7%</td>
</tr>
<tr>
<td>Begin. New 9-Weeks</td>
<td>59.8%</td>
<td>22.7%</td>
</tr>
<tr>
<td>Begin. New Year</td>
<td>61.8%</td>
<td>37.1%</td>
</tr>
</tbody>
</table>

Table C3
*Question 3-4: How often do you refer to the Mathematics Benchmark Test Blueprint in planning your instruction?*

<table>
<thead>
<tr>
<th></th>
<th>At Least Sometimes</th>
<th>Regularly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>42.9%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Weekly</td>
<td>59.6%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Begin. New Unit</td>
<td>83.6%</td>
<td>46.9%</td>
</tr>
<tr>
<td>Begin. New 9-Weeks</td>
<td>89.8%</td>
<td>59.2%</td>
</tr>
<tr>
<td>Begin. New Year</td>
<td>87.7%</td>
<td>61.2%</td>
</tr>
</tbody>
</table>

Table C4
*Questions 2-1, 2-2, 2-3, 3-1, 3-2, 3-3: How do teachers currently access the curriculum support documents?*

<table>
<thead>
<tr>
<th></th>
<th>Curriculum Guide</th>
<th>Benchmark Test Blueprint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Copy</td>
<td>90.7%</td>
<td>86.5%</td>
</tr>
<tr>
<td>Electronic Copy</td>
<td>68.0%</td>
<td>56.0%</td>
</tr>
<tr>
<td>Access Online</td>
<td>80.4%</td>
<td>74.5%</td>
</tr>
</tbody>
</table>
**Key Question 2**

*What characteristics of the documents do teachers find to be useful?*

**Data Sources:** Survey Questions: 2-6, 2-8, 3-5, 3-7; Focus Group Interview

**Summary of Findings:** For the Curriculum Guide, teachers find the instructional pacing to be beneficial. For both the Curriculum Guide and the Benchmark Test Blueprint, teachers find the SOL information to be beneficial. For the Benchmark Test Blueprint, teachers note that the document is easy to use and consistent with the content of the benchmark tests. Many teachers also indicate that the “Approx. # of Items” column helps them to identify the relative importance of individual topics.

**Supporting Data:** The following quotes were taken from the responses to the open-ended survey questions and participants’ comments during the focus group interview:

<table>
<thead>
<tr>
<th><strong>Curriculum Guide – Beneficial</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pacing</strong></td>
</tr>
<tr>
<td>“Gives me a guide as to how I should pace my instruction.”</td>
</tr>
<tr>
<td>“Helps guide, give a goal as to where in the curriculum the county would like me to be.”</td>
</tr>
<tr>
<td>“Nine weeks guidance to keep me on track.”</td>
</tr>
<tr>
<td>“It is a great source for keeping track of what I have taught and what I have not.”</td>
</tr>
<tr>
<td>“The suggested pacing helps keep me on track to complete material in a timely manner.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SOL Information</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>“The SOL covered in each unit are listed.”</td>
</tr>
<tr>
<td>“I like that the SOL are correlated with each EM [Everyday Mathematics, MCPS’ adopted mathematics program for K-5] lesson… aligns EM and SOL nicely.”</td>
</tr>
<tr>
<td>“…ensure that I am teaching what is expected of our grade level.”</td>
</tr>
<tr>
<td>“…easy to find SOL.”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Benchmark Test Blueprint - Beneficial</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOL Information</strong></td>
</tr>
<tr>
<td>“It's directly correlated to the SOL Test… The language to use and the related Released SOL items are helpful as well.”</td>
</tr>
<tr>
<td>“References to specific SOL test questions.”</td>
</tr>
<tr>
<td>“States exactly which part of SOL is tested.”</td>
</tr>
<tr>
<td>“Reminds me to check the SOL and make sure my assessments match them…”</td>
</tr>
</tbody>
</table>
Ease of Use

“*It's easier to read.*”

“A short list of what’s important…”

“It clearly states what is to be covered and when.”

“I like that it is straight to the point. There is no extra fluff. It is a good quick guide.”

Consistent with the Benchmark Tests

“I really appreciate that what is on the blueprint is actually the material that is covered on the benchmark [test]. We know what to expect.”

“It is an accurate description of what is on the test.”

“We very much appreciate the fact – I know I’ve talked to other third grade teachers – that what is on this math Benchmark Test Blueprint is actually what is on the benchmark [test].”

Identifies Relative Importance of Topics

“It helps me see which skills should receive more time than others.”

“Relative importance of question (number of questions).”

“…gives me a good idea of how deeply to prepare for a particular math skill.”

“… a relative importance. Like, ‘Oh, there’s only one question about classifying angles and triangles. Well, I don’t need to spend three weeks on that.’”

Key Question 3
What characteristics of the documents do teachers find to be problematic?

Data Sources: Survey Questions: 2-7, 2-8, 3-6, 3-7; Focus Group Interview

Summary of Findings: Many teachers find the Curriculum Guide to be overwhelming and difficult to use, and that it does not provide enough supplemental instructional resources. Teachers have relatively few concerns about the Benchmark Test Blueprint. Teachers feel that the usefulness of both resources is limited by the fact that they are paper documents.

Supporting Data: The following quotes were taken from the responses to the open-ended survey questions and participants’ comments during the focus group interview:

Curriculum Guide – Problematic

Difficulty of Use

“It’s lengthy.”

“Not user-friendly.”

“...has too much information that is not organized in a helpful way.”

“It’s too big, it’s just – nobody wants that clunker thing.”
**Lack of Supplemental Resources**

“I do not feel enough outside resource suggestions or supplemental lessons are suggested.”

“Wish there were additional resources…”

“There is not as much help for activities to do to delve further into concepts.”

“I’d like to see the document have a better list of resources…”

---

**Both Documents - Problematic**

**Paper Formatting**

“There’s a lot of tiny words on a page, and there’s a lot of pages. And it makes me think ‘headache’.”

“There’s too much on one page.”

“It repeats a lot of things that don’t always seem to be helpful to me.”

“It does not have hyperlinks to the SOL-type questions to illustrate the assessment used.”

---

**Key Question 4**

*What changes to the design and content of the documents do teachers believe would increase the documents’ usefulness?*

**Data Sources:** Survey Questions: 2-8, 3-7; Focus Group Interview

**Summary of Findings:** Teachers believe that three changes would increase the documents’ usefulness: separating the pacing information from the resources; expanding the supplemental resources and re-organizing them by Standard of Learning; and converting to an online format.

**Supporting Data:** The following quotes were taken from the responses to the open-ended survey questions and participants’ comments during the focus group interview:

---

**Changes to Increase Usefulness**

**Separating the Pacing from the Resources**

“It would almost be nice to have one document that’s just the overview at-a-glance…”

“I’m picturing separately. I want a quick glance, I’ll go here. From my quick glance I need more information, I’ll go get this thing… I don’t want to fumble through it all.”

“I would like to have when I’m supposed to get it done… what the SOL is, what the unit is – there it is, boom. If I need more, I’ll go to the online stuff.”

“We could do a separate pacing to take care of when it falls, and then have the resources organized in a manner that makes more sense.”
Expanding and Re-organizing the Resources

“…stories and picture books…”

“…links to different online games and activities.”

“SMART Board [resources].”

“[Guidance to make sure that we understand] the content ourselves.”

“…something that would tell us the background knowledge this child needs…”

“I would love ideas for how to do those hands-on activities to build that background knowledge.”

“…the resources organized by SOL, or by strand [of SOL]…”

“I would rather it be organized by SOL…”

“I want to be able to log on and pull this [the Curriculum Guide] up easy and click on SOL – say 2.11… and say, ‘This is 2.11, this is everything that you could do with it…’ and then I can say, ‘Bye’ and close it and I’m done.”

Converting to an Online Format

“… I am drowning in paper.”

“I don’t need another binder full of this.”

“I’d also like to see it have a greater technology side to it… if it were online, to click on a link and take you directly to a game, or directly to a web site.”

“I would rather if it was online… Because my plan book is on my computer, I could just drop it in – copy and drop it right in where I need it.”

“I would like for there to be an online version that links to different online games and activities. It would be easier for me to plan if it was all included online.”

The focus group interview provided additional data supporting the suggested changes. In summarizing the interview, the evaluator restated each of the changes to ensure that the participants’ views were being portrayed accurately. Participants were unanimous in their support of all three recommendations.
Recommendations

Expand Supplemental Resources.

While teachers consistently used the current documents when planning their instruction, they did not use them as consistently to find supplemental resources. The responses to the open-ended survey questions and the comments during the focus group interview indicated that this is because the documents are lacking in this area. Suggestions for expanded resources included: links to online games and instructional content; PowerPoint presentations; SMART Board lessons; and lists of children’s literature aligned to mathematical topics. Teachers also recommended the creation of a lending library for math materials that are not available in every school. In addition, teachers desired resources related to the teaching and learning of mathematics that will help them better understand children’s mathematical development and guide their instruction to promote student understanding of key concepts.
Appendix C

Research Team: First Meeting Agenda

4:00 - 4:30 p.m. – Full Team

0. Ground rules
1. Introductions

   **Facilitator:** Jonathan Schulz, Mathematics Supervisor
   
   **Design Group:** [DGT1] - 4th, [DGT2] - 4th, [EIS1], [EIS2]
   

2. What is design research? (handout & .ppt)
3. Project goal: Explore the potential of Curriculum Support Materials for developing elementary mathematics teachers’ understanding of teaching as a design activity and supporting those teachers in engaging in teaching as design. (“Re-professionalizing teachers.”)

4. Time line

5. Paperwork (consent forms, etc.)

4:30 – 5:30 p.m. – Design Group Only

1. Tasks – Analysis Phase (by ~ March 1st)
   a. Establish a common understanding of teaching as design (identify characteristic behaviors?)
   b. Decide what we want teachers to understand about teaching as design
   c. Begin development of professional development resources related to teaching as design
   d. Identify the “big idea” mathematics topic around which we will organize our CSM prototype (cross grade-level)

2. Communicating through Scholar – setting expectations
4. Schedule next DG meeting
5. Exit slip:
   a. What do you need to know more about in order to begin working?
   b. What have I missed?
Appendix D

CSM Web Site: Complete Screen Captures

CSM Web Site: Teaching Math - Home

**Our Mission**

Schools strives to promote comprehensive mathematical literacy by providing effective classroom instruction that incorporates intervention and extension opportunities to support all learners.

Our K-12 Mathematics program emphasizes a balance between factual knowledge, procedural fluency, and conceptual understanding. Our instruction consistently provides students with opportunities for problem solving, reasoning and proof, communication, identifying connections, and creating and analyzing multiple representations of mathematical ideas. Our instructional decisions are guided by formative assessment data to ensure that all students receive a high-quality mathematics education.

"A school mathematics curriculum should provide a road map that helps teachers guide students to increasing levels of sophistication and depths of knowledge."

- NCTM (2000)

"The essential value of curriculum is how it permits teachers to adapt, invent and transform as they confront the realities of classroom life."

- Lee Shulman (1990)

**Our Vision**

We believe that our teachers are decision makers who use curriculum materials as tools to meet their instructional goals.

We view teaching as a design activity that requires planning backward from our established goals, identifying essential student understandings, diagnosing our students' needs, crafting units and lessons to meet those needs, gathering evidence of our students' progress, and engaging in ongoing analysis and reflection to improve our students' learning.
Teaching as Design

1. **design** verb (di’zên) — to create, fashion, execute, or construct according to plan

"Teachers are designers. An essential act of our profession is the crafting of curriculum and learning experiences to meet specified purposes. We are also designers of assessments to diagnose student needs to guide our teaching and to enable us, our students, and others (parents and administrators) to determine whether we have achieved our goals."

Common Practices of Design Professions

Several authors (e.g., Wiggins & McTighe; M. W. Brown; Stepanek, et al.) have noted the connections between teaching and design professions such as architecture, engineering, and graphic arts:

- Identifying and framing problems and needs
- Working collaboratively
- Gathering and analyzing information
- Determining performance criteria for successful solutions
- Generating and implementing solutions
- Evaluating outcomes

- Stepanek, Leong, Griffin, & Lavelle (2011)

Our Approach

Some of these authors have also created professional development systems intended to promote teaching as design (e.g., Understanding by Design). However, instead of implementing one of these complex (and often rather prescriptive) systems for our teachers, we’re taking a simpler approach.

The basic ideas of teaching as design are actually pretty straightforward, and we believe that most teachers would consider these ideas to be “just good teaching”. We also believe that, with a little background information and a few simple supports, most teachers can begin implementing these ideas into their mathematics teaching fairly quickly.

Getting Started
CSM Web Site: Teaching Math – Getting Started (Part 1)

Getting Started
We have created the following resources with two goals in mind:

- To help teachers understand teaching as design; and
- To help teachers begin to engage in teaching mathematics as design.

Let's begin by looking at what we consider to be the essentials.

The Essential Features of Teaching as Design

1. Planning Backward from Your Learning Goals
   To begin with the end in mind means to start with a clear understanding of your destination. It means to know where you're going so that you better understand where you are now so that the steps you take are always in the right direction.

   - Stephen Covey, The 7 Habits of Highly Effective People (1989)

The first essential feature of teaching as design is deceptively simple: plan backward. This is an effective strategy for reaching any goal in life and it can be especially useful for teachers in reaching their instructional goals; however, it can be surprisingly challenging to establish those goals, especially in mathematics.

The Virginia Standards of Learning for Mathematics provide a nice list of the things that students should know and be able to do, but they aren't very helpful when it comes to the things that students should understand. If we focus our instruction only on the Standards of Learning, we run the risk of producing students who can "do" lots of things, but who don't understand how those things work or why we wanted them to learn how to do them in the first place. Recent national and international test results support the idea that being proficient with skill-based standards like our SOL does not necessarily translate to understanding mathematics.

Instead, we want to help teachers begin their planning by considering:
- What are the big ideas of elementary mathematics that I want to address?
- What do my students need to understand about those big ideas?
- What do they need to know and be able to do?
We believe that, if we can help teachers connect the Standards of Learning to the big ideas, it will help students develop the conceptual understandings that give meaning to the facts they know and the procedures they can do. We think this might be a better way to develop students who approach problem-solving like this.

ASCD Article: *Backward Design for Forward Action* by Wiggins and Thomas

2. **Selecting Your Assessments First**
   *How will we know if students have achieved the desired results? What will we accept as evidence of student understanding and proficiency?*


   This idea may represent a significant shift from your current practice, but it's a logical extension of planning backward: Once you've decided what you want your kids to learn, how will you decide if they've learned it? This is a key step in aligning your instruction with your goals.

   We want to help teachers begin to use assessments that provide evidence of students' proficiency with the SOL as well as their understandings of the big ideas.

   Wiggins & McTighe's *Types of Evidence*
   Dan Mulligan's *Checklist for Assessment Development*

3. **Reviewing Available Resources**
   *Teachers must perceive and interpret existing resources, evaluate the constraints of the classroom setting, balance tradeoffs and devise strategies - all in the pursuit of their instructional goals.*


   "Wait - you mean I don't just teach the program?"

   Yes, that's what we're saying. We believe that teachers are decision-makers who use curriculum materials as tools to meet their goals. Our new math program is great, but implementing it mechanically will not get the job done.

   Our job is to teach the SOL (it's the law), and now we've added a focus on teaching big ideas to help students better understand the SOL; teachers need the freedom (and the ability) to evaluate and select instructional resources in order to craft learning experiences that will help our students reach these goals.
4. **Matching Your Instruction to Your Goals and Assessments**

With clearly identified results and appropriate evidence of understanding in mind, it is now time to fully think through the most appropriate instructional activities.


This one may seem like a no-brainer, but ask yourself this: Have you ever taught a math lesson mostly because it was the next one in the book? Every one of us has done this at some point (and it’s not always a bad thing), but we think it makes sense to try to stop and think along the way, "What are my goals again?"

5. **Using Formative Assessment**

*Informative assessment isn't about "after."*


<table>
<thead>
<tr>
<th></th>
<th>Formative Assessment</th>
<th>Summative Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>When?</strong></td>
<td>During</td>
<td>After</td>
</tr>
<tr>
<td><strong>Typically Graded?</strong></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Purpose?</strong></td>
<td>Guiding Instruction</td>
<td>Accountability</td>
</tr>
<tr>
<td><strong>Who’s it for?</strong></td>
<td>Teachers and Students</td>
<td>All Stakeholders</td>
</tr>
</tbody>
</table>

The simplest way to understand the difference between formative and summative assessment is to think of formative assessment as "assessment for learning" and summative assessment as "evaluation of learning." Using formative assessments allows to check your bearings throughout your instruction to help you stay on the course you've set.

Think of it as progress monitoring for yourself: "Are my students learning what I think they are?" Formative assessment gives you time to adjust your instruction.

**NCTM Research Clip:** [*What is formative assessment?*](#)

**NMSA Article:** [*Formative and Summative Assessments in the Classroom*](#)

**ASCD Article:** [*Learning to Love Assessment*](#) by Carol Ann Tomlinson
Ready to Give it a Whirl?

*Just do it.* - *Nike (1988)*

Okay, so we realize that's a lot of information, but seriously: Other than asking you to create your assessments before you plan your instruction, is there really anything that earthshaking here? These are fantastic ideas, but their beauty lies in their simplicity.

The next section will introduce you to a planning tool to help you get started.

The Unit Planning Checklist

(For the record, we should mention that Wiggins & McTighe also thought it was clever to quote the Nike slogan in the "Getting Started" section of their book, *Understanding by Design*; we'd like to point out, however, that they didn't get around to discussing how to get started until page 322 - in the Afterword!)
The Unit Planning Checklist

The authors who have created professional development systems to promote teaching as design use (and sell) a lot of resources intended to guide teachers through the process:

"We have found that an array of scaffolds – prompts, organizers, ideas sheets, and examples – help educators produce higher-quality designs. A full set of these resources is available in the UbD Professional Development Workbook."

- Wiggins & McTighe, Understanding by Design, p. 29

We disagree with this approach, because the sheer volume of planning resources required to use these systems can seem overwhelming - and may even reduce teachers' willingness to try teaching as design. Instead, we've provided one planning tool to help you get started.

Not Just Another Lesson Plan Template

Apparently, a lot of people think that the best way to get teachers to change what they do is to require prescribed lesson plans: Googling "lesson plan template" yields 3,650,000 results in 0.15 seconds, so creating yet another one doesn't seem like it would be very helpful.

We believe that our teachers are already doing a great job with planning and teaching – we just want to shift our teachers' thinking a little during the process.

The purpose of this Unit Planning Checklist is to help you remember to think about those Essential Features of Teaching as Design. You can download the checklist here.
# Unit Planning Checklist

<table>
<thead>
<tr>
<th>Before</th>
<th>During</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Establish Learning Goals</strong></td>
<td><strong>Assess Student Learning</strong></td>
<td><strong>Assess Student Learning</strong></td>
</tr>
<tr>
<td>- Identify the big idea(s)</td>
<td>- Collect formative assessment data</td>
<td>- Collect summative assessment data</td>
</tr>
<tr>
<td>- Students should understand...</td>
<td>- Analyze student understandings</td>
<td>- Analyze student understandings</td>
</tr>
<tr>
<td>- Students should know...</td>
<td>- Plan for re-teaching</td>
<td>- Plan remediation for struggling students</td>
</tr>
<tr>
<td>- Students should be able to...</td>
<td>- Review/revise remaining lessons</td>
<td></td>
</tr>
<tr>
<td>- Review VDOE Curriculum Framework</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Select/Modify/Create Assessments</strong></td>
<td><strong>Consider Instructional Grouping Options</strong></td>
<td><strong>Reflect on the Unit</strong></td>
</tr>
<tr>
<td>- Pre-assessments</td>
<td>- Whole class</td>
<td>- Which lessons were successful?</td>
</tr>
<tr>
<td>- Formative assessments</td>
<td>- Groups</td>
<td>- Which lessons need to be revised?</td>
</tr>
<tr>
<td>- Summative assessments</td>
<td>- Centers</td>
<td></td>
</tr>
<tr>
<td>- Variety of assessment formats</td>
<td>- One-on-one</td>
<td>- Which assessments were helpful?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Which assessments need to be revised?</td>
</tr>
<tr>
<td><strong>Review Available Resources</strong></td>
<td><strong>Plan for Available Support Staff</strong></td>
<td>- Review lesson sequence</td>
</tr>
<tr>
<td>- Textbook materials</td>
<td>- Special Education / RTI</td>
<td></td>
</tr>
<tr>
<td>- Supplementary materials</td>
<td>- Instructional Specialist</td>
<td></td>
</tr>
<tr>
<td>- Enhanced Scope &amp; Sequence</td>
<td>- Gifted Resource Teacher</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Tutors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Pre-service teachers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Volunteers</td>
<td></td>
</tr>
<tr>
<td><strong>Select Lessons/Activities</strong></td>
<td></td>
<td><strong>Plan connections to future units</strong></td>
</tr>
<tr>
<td>- Logical sequence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Connections to learning goals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Connections to SOL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Resources by Topic

This page will eventually link to multiple pages of resources organized around important topics and emphasizing the big ideas of elementary mathematics.

Our first set of these curriculum support materials can be found here: Introducing Multiplication and Division

Please remember to try “hovering” over the links on the following pages - many of them will give you additional information about the resources this way.

Click here to download the SMART Notebook file used throughout the following videos.

Download “What operation is it?” to try it with your students.
**The Big Idea**

**Equal Groups:** Whole number multiplication and division are related operations used to describe situations involving equal groupings of objects.

**Students should understand that...**

1. Multiplication and division are closely related to each other.
2. Multiplication involves equal groups.
3. Division involves equal groups.
4. Multiplication and division describe the same situation, just with different unknowns:
   - Multiplication - "unknown-product" problems
   - Division - "unknown-factor" problems

---

**Quick Navigation**

- Introducing Multiplication and Division
- Students should be able to...
  1. Interpret Products
  2. Interpret Quotients
  3. Solve Word Problems
  4. Determine Unknown Number in Equation
Students should know that...

1. Each number in a multiplication or division number sentence has meaning depending on the context: the number of groups, the number of objects in each group, and the total number of objects.
2. Division involving equal groups has two meanings: fair-sharing (divvying up) to find an unknown group size; and partitioning (measuring out equal-sized groups) to find an unknown number of groups.
3. Multiplication and division can be represented by equal groups, arrays, and equal-sized "jumps" on a number line (skip-counting).
Students should be able to...

Click on the links below for assessments and other instructional resources related to each "Should be able to...".

1. **Interpret products** of whole numbers.
2. **Interpret whole-number quotients** of whole numbers.
3. Use multiplication and division to **solve word problems** involving equal groups, arrays, and number lines.
4. **Determine the unknown whole number in a multiplication or division equation** relating three whole numbers.

For example...

3) By using drawings and equations with a symbol for the unknown number to represent the problem.
Students should be able to...

Interpret products of whole numbers.

“Note that, because interpreting products and interpreting quotients are so closely related, many of the resources for “Be able to…” #1 may be appropriate for “Be able to…” #2 and vice versa.

Related Standards

2009 SOL 3.6
The student will represent multiplication and division, using area, set, and number line models, and create and solve problems that involve multiplication of two whole numbers, one factor 99 or less and the second factor 5 or less.

Related Essential Understanding from the Curriculum Framework: All students should understand the meanings of multiplication and division.

Common Core Standard 3.OA.1
Interpret products of whole numbers.
Assessments

Example: "Write a number story in which the total number of objects can be represented by 5 x 7. Draw a picture to match your story and write a multiplication equation to show the product."

Houghton-Mifflin Expressions Assessment Resources

"Groups of" Models of Multiplication
- Gr2 Act. Card 13.2 - On Level
- Gr2 Act. Card 13.3 - On Level
- Gr2 Homework 13.1
- Gr2 Homework 13.2
- Gr2 Homework 13.3

Array Models of Multiplication
- Gr2 Homework 13.4 (#4)
- Gr2 Act. Card 13.5 - On Level
- Gr2 Act. Card 13.5 - Chal.
- Gr2 Homework 13.5

Assessment Suggestions

"Extending the Assessment" (Gr2 TE p. 1040)
Once the online TE opens, type in the desired page number.

Informal Checks for Understanding:
Try observing your students (or a targeted group) as they complete the Activity Cards. Create a simple checklist, listing students' names down the left-hand side of the page, a few "look fors" that you are interested in across the top of the page, and keep track of who "got it" and who didn't.

Gr2 Lesson 13.1 (p. 953): Circulate around the room during this lesson and ask students to skip count by 2's, point out a multiplication symbol, and/or what the numbers in a multiplication equation mean.

Academic Prompts:  Cups and Marbles

Quiz and Test Items:  MCPS_Sample_Items  HME_Gr2_Unit_13_Quick_Quiz_1
CSM Web Site: Teaching Math – IMD – Interpret Products (Part 3)

# Teaching Resources

**Houghton-Mifflin Expressions Teaching Resources**

**Related Units:**
- Grade 2 Unit 13 (p. 953A)
- Grade 3 Unit 7 (p. 457A)

*Once the online TE opens, type in the desired page number.*

**Some Suggestions:**

**Grade 2 Unit 13**
- Notice that the "Keeping Skills Sharp" section of each lesson (e.g., p. 953) has students practice important skills such as skip counting and drawing arrays and equal groups models on the 120 poster.

- Lessons 1-3 focus on equal groups models. Students examine the patterns for skip counting by 2's, 3's, and 4's and make connections to between skip counting and multiplication equations. Check out "The Learning Classroom" (sidebar, p. 962) and Differentiated Instruction Extra Help (sidebar, p. 958).


- Lessons 4-5 focus on array models. Check out "Teaching Note - Language and Vocabulary" (sidebar, p. 975) and "Teaching Note - Watch For" (p. 976).

  *Student Activity Book p. 432  p. 433  p. 434*

**Online Resources:**

**Soar to Success**
- Topic 12. Multiplying Whole Numbers - [Lesson 19: Use Repeated Addition to Multiply...]
- Topic 12. Multiplying Whole Numbers - [Lesson 23: Use Arrays to Multiply...]

**Mega Math**
- Fraction Action. Number Line Mine - [D. Multiplication Facts]
- Numberropolis. Carnival Stories - [S. Multiplication Stones]

**Destination Math**
- Repeated Addition and Arrays

**Additional Teaching Resources**

SMART Exchange:
- Arrays of Apples
**Students should be able to...**

**Interpret whole-number quotients of whole numbers.**

"Note that, because interpreting products and interpreting quotients are so closely related, many of the resources for "Be able to..." #1 may be appropriate for "Be able to..." #2 and vice versa.

**Related Standards**

**2009 SOL 3.6**
The student will represent multiplication and division, using area, set, and number line models, and create and solve problems that involve multiplication of two whole numbers, one factor 99 or less and the second factor 5 or less.

Related *Essential Understanding* from the Curriculum Framework: All students should understand the meanings of multiplication and division.

**Common Core Standard 3.OA.2**
Interpret whole-number quotients of whole numbers.
CSM Web Site: Teaching Math – IMD – Interpret Quotients (Part 2)

**Assessments**

**Example:** "Write a number story in which the number of equal groups of objects (or the number in each equal group) can be represented by $24 \div 6$. Draw a picture to match your story and write a division equation to show the quotient."

**Houghton-Mifflin Expressions Assessment Resources**

- **Ongoing Assessment** (Gr3 TE, p. 496)
- **Gr3 Act. Card 7.4 - Interv.**
- **Gr3 Act. Card 7.4 - On Level**

**Assessment Suggestions**

**Informal Checks for Understanding:** Keep an eye out for the Math Writing Prompts (in the sidebar of the TE, next to the Activity Cards). These prompts are great tools that could also be used orally for a quick assessment interview with a targeted student.

- **Academic Prompts:** Pasta and Paper Plates
- **Quiz and Test Items:** MCPS Sample Items
Teaching Resources

Houghton-Mifflin Expressions Teaching Resources

Related Units:
Grade 2 Unit 13 (p. 953A) Grade 3 Unit 7 (p. 457A)
Once the online TE opens, type in the desired page number.

Some Suggestions:
Grade 2 Unit 13
- Lesson 6: Try the "Home or School Activity", reading The Doorbell Rang to the class and asking students to model and discuss the fair-sharing situations that arise.

- Lesson 7 (Activities 1-3): Students are put into to groups to model fair-sharing problems and discuss division. Check out the "Math Talk in Action" section (Gr2 TE, p. 992). If you use the Intervention Activity Card, you may want to ask students to tell number stories that match the equations that they are modeling with counters.

Grade 3 Unit 7
- Lesson 4: Emphasizes the connections between multiplication and division. Take a look at "Alternate Approach" (sidebar, p 491) and the "Teaching Note" (sidebar, p. 492).

Student Activity Book p. 217 p. 218

Online Resources:

Destination Math
Meaning of Division

Additional Teaching Resources

SMART Exchange:
Arrays of Apples
Students should be able to...

Use multiplication and division to solve word problems involving equal groups, arrays, and number lines.

Related Standards

2009 SOL K.4 1.2 2.4
Counting by 1's; skip counting by 2's, 5's, and 10's; recognizing even and odd numbers.

2009 SOL 3.2
The student will recognize and use the inverse relationships between addition/subtraction and multiplication/division to complete basic fact sentences. The student will use these relationships to solve problems.

2009 SOL 3.6
The student will represent multiplication and division, using area, set, and number line models, and create and solve problems that involve multiplication of two whole numbers, one factor 99 or less and the second factor 5 or less.

Common Core Standard 3.OA.3
Use multiplication and division within 100 to solve word problems in situations involving equal groups, arrays, and measurement quantities, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem.
Assessments

Examples:
The following table is excerpted from the Common Core Standards for Mathematics.

<table>
<thead>
<tr>
<th>Unknown Product</th>
<th>Group Size Unknown</th>
<th>Number of Groups Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3 \times 6 = ?$</td>
<td>$3 \times ? = 18$, and $18 \div 3 = ?$</td>
<td>$? \times 6 = 18$, and $18 \div 6 = ?$</td>
</tr>
</tbody>
</table>

**Equal Groups**
- There are 3 bags with 6 plums in each bag. How many plums are there in all?
  - Measurement example. You need 3 lengths of string, each 6 inches long. How much string will you need altogether?
- If 18 plums are shared equally into 3 bags, then how many plums will be in each bag?
  - Measurement example. You have 18 inches of string, which you will cut into 3 equal pieces. How long will each piece of string be?
- If 18 plums are to be packed 6 to a bag, then how many bags are needed?
  - Measurement example. You have 18 inches of string, which you will cut into pieces that are 6 inches long. How many pieces of string will you have?

**Arrays, Area**
- There are 3 rows of apples with 6 apples in each row. How many apples are there?
  - Area example. What is the area of a 3 cm by 6 cm rectangle?
- If 18 apples are arranged into 3 equal rows, how many apples will be in each row?
  - Area example. A rectangle has area 18 square centimeters. If one side is 3 cm long, how long is a side next to it?
- If 18 apples are arranged into equal rows of 6 apples, how many rows will there be?
  - Area example. A rectangle has area 18 square centimeters. If one side is 6 cm long, how long is a side next to it?

*The language in the array examples shows the easiest form of array problems. A harder form is to use the terms rows and columns: The apples in the grocery window are in 3 rows and 6 columns. How many apples are there? Both forms are valuable.

**Houghton–Mifflin Expressions Assessment Resources**
- Gr3 Homework 7.7
- Gr3 Homework 7.11
- Gr3 Lesson 7.11 Activity 3 (SAB p. 248)

Assessment Suggestions

"Extending the Assessment" (Gr3 TE p. 608)
Once the online TE opens, type in the desired page number.

Informal Checks for Understanding:
"Home or School Activity: Art Connection" (Gr3 TE p. 558) - This activity asks students to draw a picture of a word problem and share it with the class. Try asking questions about the decisions students made when creating their drawings as a way of assessing their understanding of the meanings of the operations.

Academic Prompts:
Marching Band Activity - This is the Gr2 Unit 13 Performance Assessment (found in the Gr2 Assessment Guide), which asks students to create arrays for a 12-person marching band.

Quiz and Test Items: MCPS Sample Items
CSM Web Site: Teaching Math – IMD – Solve Word Problems (Part 3)

Teaching Resources

_Houghton-Mifflin Expressions Teaching Resources_

**Related Units:**
- **Grade 2 Unit 13** (p. 953A)  
- **Grade 3 Unit 7** (p. 457A)

*Once the online TE opens, type in the desired page number.*

**Some Suggestions:**

**Grade 2 Unit 13**
- Lesson 1 (Activity 1, TE p. 954): Students are given number stories and asked to write the corresponding repeated addition and multiplication equations. Try extending this activity by asking students to draw models to represent the stories as well.  
  _Student Activity Book p. 417_

- Lesson 7 (Activities 1-2, TE p. 992): Great introduction to division (explores measuring out as well as divvying-up). Check out the "Teaching Note" (sidebar, p. 993). All three Activity Cards (Intervention, On Level, Challenge) ask students to model division using counters to build arrays.  
  _Student Activity Book p. 437_

**Grade 3 Unit 7**
- Lesson 5: Even though the lesson focuses on the fact patterns for 2's, the homework has great multiplication and division word problems.

- Lesson 8 (Activity 4): Mixed word problems; check out the "Teaching Note" (Gr3 TE, p. 530). The homework does a nice job of showing how the same word problem can be solved using multiplication or division.  
  _Student Activity Book p. 235_

**Online Resources:**

**iTools - Primary - Counters**

**Mega Math**
- Country Countdown. Counting Critters - _V. Repeated Addition as Multiplication_
- Country Countdown. Counting Critters - _W. Multiply with Arrays_
- Country Countdown. Counting Critters - _X. Size of Groups_
- Country Countdown. Counting Critters - _Y. Number of Groups_

**Destination Math**
- Finding Products Less than 100

**Additional Teaching Resources**

**Candy Arrays Lesson Plan**  
**Candy Arrays SMART Notebook File**

**NCTM Illuminations:**
- "All About Multiplication" Unit:  
  - Lesson 1  
  - Lesson 2  
  - Lesson 3  
  - Lesson 4  
- Dynamic Paper

**ictgames.com: Numberline Jump Maker**
**Students should be able to...**

**Determine the unknown whole number in a multiplication or division equation relating three whole numbers.**

**Related Standards**

<table>
<thead>
<tr>
<th><strong>2009 SOL 2.21</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The student will solve problems by completing numerical sentences involving the basic facts for addition and subtraction. The student will create story problems, using the numerical sentences.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>2009 SOL 2.22</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The student will demonstrate an understanding of equality by recognizing that the symbol = in an equation indicates equivalent quantities and the symbol ≠ indicates that quantities are not equivalent.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>2009 SOL 3.2</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The student will recognize and use the inverse relationships between addition/subtraction and multiplication/division to complete basic fact sentences. The student will use these relationships to solve problems.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>2009 SOL 3.5</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>The student will recall multiplication facts through the twelves table, and the corresponding division facts.</td>
</tr>
</tbody>
</table>

Common Core Standard 3.OA.4

| Determine the unknown whole number in a multiplication or division equation relating three whole numbers. |
Assessments

Examples:

<table>
<thead>
<tr>
<th>6 x 3 = ?</th>
<th>? ÷ 6 = 3</th>
<th>6 x ? = 18</th>
<th>18 ÷ 6 = ?</th>
<th>? x 3 = 18</th>
<th>18 ÷ 3 = ?</th>
</tr>
</thead>
</table>

*Houghton Mifflin Expressions Assessment Resources*

G3 Homework 7.4

Assessment Suggestions

**Informal Checks for Understanding:** When working with fact triangles, instead of asking students to find a missing number, just cover up one of the numbers and ask students to write the equation that they see (note that some students may see a multiplication equation while others may see a division equation for the same example).

**Academic Prompts:** Ask students to choose a multiplication/division fact family and then write four different open number sentences (i.e., equations with a missing number - see examples above) for that fact family.

**Quiz and Test Items:** MCPS Sample Items
Teaching Resources

_Houghton-Mifflin Expressions Teaching Resources_

**Related Units:**
- Grade 2 Unit 13 (p. 953A)  
- Grade 3 Unit 7 (p. 457A)

*Once the online TE opens, type in the desired page number.*

**Some Suggestions:**
- Grade 3 Unit 7
  - Student Activity Book p. 219

**Additional Teaching Resources**

- [elementarysoftware.com:Terrific Triangles](http://elementarysoftware.com)
- [Fact_Triangles_SMART_Notebook_Activity](http://fact_triangles.smarten_up.com)
- [nrich.maths.org:Number_Balance](http://nrich.maths.org)
  (Check out the video below.)
Appendix E

Job Description: Supervisor of Mathematics

TITLE: Supervisor of Mathematics

PRIMARY FUNCTION: Coordinate the PK-12 math program.

ESSENTIAL FUNCTIONS:

- Developing curriculum and curriculum guides for each level of math being taught throughout the division
- Analyzing standardized test data and guiding teachers and administrators in using data to improve instruction
- Preparing reports, conducting needs assessments, and interpreting data for math
- Developing strong collaborative, positive communications with community and school members
- Providing and maintaining relevant professional development programs and resource materials for math
- Working with teachers to implement best practices in the teaching of mathematics
- Collaborating with universities to facilitate current and future grant programs
- Responding to the School Board, school administrators, department heads, and teachers regarding specific curriculum and Standards of Learning issues and concerns
- Assisting the School Board, school administrators, and department heads to read and understand all available data to help meet stat accreditation standards and AYP
- Assisting school administrators in screening and interviewing staff for math positions
Appendix F

Implementation Group: Planning and Teaching Logs

Planning & Teaching Log #1: Unit Planning
Describe your planning/preparation for this math unit, including:
- estimates of the amount of time spent planning/preparing
- any resources that you used and how/why you used them

Please revisit this section of the log as needed throughout the 10-day period.

Planning & Teaching Log #1: Day 1
Date: ____________
1) Describe your planning/preparation for today’s math lesson, including an estimate of the amount of time spent planning/preparing.
2) What were your goals for today’s lesson?
3) How does this lesson fit into the larger unit?
4) What resources did you use in your planning/preparation? How did you use them?
5) What did your students do during your math time today?
6) What did you do during your math time today?
7) Was this lesson successful? How do you know?
8) What’s next?

Planning & Teaching Log #2: Unit Planning - Pilot Unit: Monday 5/16/11 – Friday 5/27/11
Describe your planning/preparation for this math unit, including:
- estimates of the amount of time spent planning/preparing
- any resources that you used and how/why you used them (please be specific when referring to any resources that you used from the Teaching Math web page and how/why you used them)

Please revisit this section of the log as needed throughout the 10-day period.

Planning & Teaching Log #2: Day 1 - Pilot Unit: 5/16-5/27/11
Date: ____________
1) Describe your planning/preparation for today’s math lesson, including an estimate of the amount of time spent planning/preparing.
2) What were your goals for today’s lesson?
3) How does this lesson fit into the larger unit?
4) What resources did you use in your planning/preparation? How did you use them? (Please provide specific details about your use of any resources from the Teaching Math web site.)
5) What did your students do during your math time today?
6) What did you do during your math time today?
7) Was this lesson successful? How do you know?
8) What’s next?
Appendix G

Implementation Group: Individual Interview Protocol

Individual Interviews

These 60-minute individual interviews will be conducted after the IG members have completed the first 10-day teaching log and before they begin the pilot unit. The goal of these one-hour interviews is to understand as much as possible about the teaching backgrounds and mind sets of these teachers, which may be helpful for understanding their experiences with the pilot unit and interpreting their evaluations of the CSM. Participants’ responses to the demographic survey (administered in February 2011) may be used to guide my choice of follow-up questions.

These questions will be asked of all four Implementation Group members:

1. How did you come to teaching as your profession?
2. Describe your personal experiences as a learner of mathematics.
3. Describe your preparation as a mathematics teacher, including any influential courses or professional development in which you have participated.
4. How would you describe yourself as a math teacher?
5. How do you think your students would describe you as a math teacher?
6. Describe your typical process for planning your mathematics instruction.
7. Did you notice anything surprising or interesting about your mathematics teaching as you kept your planning/teaching log?

Follow up questions may be used to probe for more information. For example:

- How?
- Can you give me an (another) example?
- Can you list…?
- Why / why not?
- Can you tell me more about ________?
- I noticed…
Appendix H

Implementation Group: Post-Unit Questionnaire

**Implementation Group Questionnaire**

*Please complete this questionnaire after teaching the pilot unit (5/16 – 5/27/11) and before attending the focus group interview on Tuesday 5/31/11.*

Estimated Time Required to Complete Questionnaire: 60 minutes

This questionnaire is intended to give you a chance to reflect on your experiences with the pilot unit before our focus group interview next week. Our hope is to capture details of your individual experience to complement our group discussion. Please refer to your planning and teaching logs as needed when completing this questionnaire.

Please type and save your responses within this Word document. Thank you for your time!

---

**IG Member Name:**

1. Describe your planning and instruction throughout the unit, including the decisions you made in developing lessons, selecting instructional resources, and creating assessments.
2. Describe how you used the Teaching Math web site throughout the unit. Please be as specific as possible regarding which features you used and how and why you used them, as well as any resources that you found to be problematic.
3. Discuss the impact, if any, of the Teaching Math web site on your actions during this unit (e.g., Did you do anything differently?)
4. Discuss your perceptions of the potential of the Teaching Math web site for helping teachers understand teaching as design.
5. Discuss your perceptions of the potential of the Teaching Math web site for helping teachers begin teaching as design.
6. Describe any suggested revisions or additions to the Teaching Math web site that you believe could improve its usefulness.
## Appendix I

Implementation Group: Focus Group Interview Protocol

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:00-4:10  p.m.</td>
<td>1. Welcome and Housekeeping:</td>
<td>a) Welcome participants to session and thank them for coming.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) “Frame” this focus group interview: The purpose of the interview is to learn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>from the Implementation Group in order to understand their experiences with</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the Curriculum Support Materials (CSM), evaluate the strengths and</td>
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<td></td>
<td></td>
<td>weaknesses of the CSM in promoting teaching as design, and inform the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>design of future CSM to meet teachers’ needs.</td>
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<tr>
<td>4:10-4:55  p.m.</td>
<td>2. Discussion</td>
<td>a) Describe your overall experiences with the pilot unit. How did you use the</td>
</tr>
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<td></td>
<td></td>
<td>CSM to support your planning and instruction?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) What characteristics of the CSM did you find to be the most helpful?</td>
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<tr>
<td></td>
<td></td>
<td>c) What characteristics of the CSM did you find to be problematic or not</td>
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<tr>
<td></td>
<td></td>
<td>helpful?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) What parts of the CSM did you use the most?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) What parts of the CSM did you use the least (or not at all)?</td>
</tr>
<tr>
<td>4:55-5:20  p.m.</td>
<td>3. What changes or additions to the design and content of the CSM do you believe</td>
<td>a) Problem-solving to address any issues raised during #2 &amp; #3 above.</td>
</tr>
<tr>
<td></td>
<td>would increase their usefulness?</td>
<td></td>
</tr>
<tr>
<td>5:20-5:30  p.m.</td>
<td>4. Closing</td>
<td>a) Exit slip:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1) “To me, the most useful feature of the CSM was…”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2) “To me, the most important improvement to the CSM would be…”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Reminders: process for reviewing transcript, use of findings, informed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>consent, and ability to opt out of the project at any time.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d) Thank you!</td>
</tr>
</tbody>
</table>

Follow-up questions may be used to probe for additional information:
- How?
- Can you give me an (another) example?
- Can you list…
- Why / why not?
- Can you tell me more about ________?
## Appendix J

**Design Group: Focus Group Interview Protocol**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
</table>
| 4:00-4:10 p.m. | 1. Welcome and Housekeeping:  
  a) Welcome participants to session and thank them for coming.  
  b) “Frame” this focus group interview: The purpose of the interview is to learn from  
     the Design Group in order to understand their experiences with the overall project,  
     evaluate the strengths and weaknesses of the design and development processes,  
     evaluate the overall potential of the CSM for promoting teaching as design, and  
     improve the design and development processes for future CSM. |
| 4:10-4:55 p.m. | 2. Discussion (Content)  
  a) Describe your overall experiences with the study.  
  b) How successful do you feel the design and development processes were?  
  c) How would you evaluate the CSM’s potential for promoting teaching as design?  
  d) What characteristics of the CSM do you think have the most potential?  
  e) What characteristics of the CSM do you think have the least potential?  
  f) What changes to the CSM would you recommend for future designs? |
| 4:55-5:40 p.m. | 3. Discussion (Process)  
  a) What characteristics of the design and development processes worked well?  
  b) What characteristics of the design and development processes were problematic?  
  c) How would you structure the design and development processes for future work?  
  d) Problem-solving to address any issues raised during 3a) and 3b) above. |
| 5:40-6:00 p.m. | 4. Closing  
  a) Exit slip:  
     1) “To me, the most useful thing about participating in this study was…”  
     2) “To me, the worst thing about participating in this study was…”  
     3) “Three things that I think future designers/developers of CSM should know  
        are…”  
  b) Questions  
  c) Reminders: process for reviewing transcript, use of findings, informed consent, and  
     ability to opt out of the project at any time.  
  d) Thank you! |

Follow-up questions may be used to probe for additional information:

- How?
- Can you give me an (another) example?
- Can you list…
- Why / why not?
- Can you tell me more about ________?
Appendix K
IRB Approval Letter

MEMORANDUM

DATE: February 7, 2011

TO: Jesse L. Wilkins, Jonathan Schulz

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires October 26, 2013)

PROTOCOL TITLE: Exploring the Potential of Curriculum Support Materials for Promoting the Teaching of Elementary Mathematics as a Design Activity

IRB NUMBER: 10-1099

Effective February 7, 2011, the Virginia Tech IRB Chair, Dr. David M. Moore, approved the new protocol for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at http://www.irb.vt.edu/policies/responsibilities.htm (please review before the commencement of your research).

PROTOCOL INFORMATION:
Approved as: Expedited, under 45 CFR 46.110 category(ies) 5, 6, 7
Protocol Approval Date: 2/7/2011
Protocol Expiration Date: 2/6/2012
Continuing Review Due Date*: 1/23/2012
*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:
Per federally regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals / work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Intern IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution
Appendix L

Citations of Copyrighted Works

Figures 1, 11, 12, and 13.
Predictive and design research approaches in educational technology research. (p. 59) [fair use]
Gravemeijer, S. McKenney & N. Nieveen (Eds.), Educational Design Research (pp. 52-66). New York,
NY. Fair Use determination follows.

The editors of the book containing this figure indicated that one purpose of the book was to
provide "examples of how… [design research] can serve the design of learning environments,
educational technology, and curriculum" (p. 5). I have used this figure to justify the structure of
the design research study I conducted for my dissertation (Figures 1 and 11). I have also
modified this figure to highlight the key features of design research and to provide the basis for
my recommendations for enhancing the credibility of design research (Figures 12 and 13).

Fair Use Checklist
Copyright Advisory Office
Columbia University Libraries
Kenneth D. Crews, Director
http://copyright.columbia.edu

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Opposing Fair Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favoring Fair Use</td>
<td>Opposing Fair Use</td>
</tr>
<tr>
<td>Teaching (including multiple copies for classroom use)</td>
<td>Commercial activity</td>
</tr>
<tr>
<td>Research</td>
<td>Profiting from the use</td>
</tr>
<tr>
<td>Scholarship</td>
<td>Entertainment</td>
</tr>
<tr>
<td>Nonprofit educational institution</td>
<td>Bad-faith behavior</td>
</tr>
<tr>
<td>Criticism</td>
<td>Denying credit to original author</td>
</tr>
<tr>
<td>Comment</td>
<td></td>
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<tr>
<td>News reporting</td>
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<td>Transformative or productive use (changes the work for new utility)</td>
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<td>Restricted access (to students or other appropriate group)</td>
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<td>Parody</td>
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<tr>
<td>Nature</td>
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<td></td>
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<tr>
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</tr>
<tr>
<td>X</td>
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</tr>
<tr>
<td>X</td>
<td>Portion used is not central or significant to entire work</td>
</tr>
<tr>
<td>X</td>
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</tr>
<tr>
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<td>Amount is appropriate for favored educational purpose</td>
</tr>
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<td>X</td>
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<tr>
<td>X</td>
<td>Could replace sale of copyrighted work</td>
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<tr>
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</tr>
<tr>
<td>X</td>
<td>No similar product marketed by the copyright holder</td>
</tr>
<tr>
<td>X</td>
<td>Affordable permission available for using work</td>
</tr>
<tr>
<td>X</td>
<td>Numerous copies made</td>
</tr>
<tr>
<td>X</td>
<td>You made it accessible on the Web or in other public forum</td>
</tr>
<tr>
<td>X</td>
<td>Lack of licensing mechanism</td>
</tr>
</tbody>
</table>
In my review of the literature related to curriculum, I have used Oliva’s Cyclical Model when describing his work regarding the relationship between curriculum and instruction.

<table>
<thead>
<tr>
<th>Fair Use Checklist</th>
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<tbody>
<tr>
<td>Copyright Advisory Office</td>
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<tr>
<td>Columbia University Libraries</td>
</tr>
<tr>
<td>Kenneth D. Crews, Director</td>
</tr>
<tr>
<td><a href="http://copyright.columbia.edu">http://copyright.columbia.edu</a></td>
</tr>
</tbody>
</table>

**Purpose**

**Favoring Fair Use**
- Teaching (including multiple copies for classroom use)
- Research
- Scholarship
- Nonprofit educational institution
- Criticism
- Comment
- News reporting
- Transformative or productive use (changes the work for new utility)
- Restricted access (to students or other appropriate group)
- Parody

**Opposing Fair Use**
- Commercial activity
- Profiting from the use
- Entertainment
- Bad-faith behavior
- Denying credit to original author
### Nature

**Favoring Fair Use**
- Published work
- Factual or nonfiction based
- Important to favored educational objectives

**Opposing Fair Use**
- Unpublished work
- Highly creative work (art, music, novels, films, plays)
- Fiction

### Amount

**Favoring Fair Use**
- Small quantity
- Portion used is not central or significant to entire work
- Amount is appropriate for favored educational purpose

**Opposing Fair Use**
- Large portion or whole work used
- Portion used is central to or “heart of the work”

### Effect

**Favoring Fair Use**
- User owns lawfully purchased or acquired copy of original work
- One or few copies made
- No significant effect on the market or potential market for copyrighted work
- No similar product marketed by the copyright holder
- Lack of licensing mechanism

**Opposing Fair Use**
- Could replace sale of copyrighted work
- Significantly impairs market or potential market for copyrighted work or derivative
- Reasonably available licensing mechanism for use of the copyrighted work
- Affordable permission available for using work
- Numerous copies made
- You made it accessible on the Web or in other public forum
- Repeated or long-term use
Figure 4.
M. W. Brown’s Design Capacity for Enactment framework depicting the relationships between teachers and curriculum materials (2009, p. 26) [fair use]


In my review of the literature related to teaching as design, I have used Brown’s DCE framework when describing his work regarding teachers’ use of curriculum materials.

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