

Teaching by Design: Understanding the intersection of teacher practice and the design of curricular innovations

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This dissertation explores the ways that three urban middle school teachers use curriculum materials to enact a 10-week classroom science project. Unlike typical studies of implementation, this work devotes particular attention to the nature of the curriculum designs and the ways that teachers use these resources to design everyday instructional settings. I introduce a scale for characterizing teachers' differing degrees of reliance on the materials, a framework for analyzing the factors that influence teacher-tool interactions, and a theoretical perspective that characterizes differences both in teachers' individual capacities to use materials and in the overall systemic capacities of the teacher-tool partnerships.

Curriculum materials and instructional practice: The divide

Reformers have long been drawn to curriculum materials as a mechanism for influencing the practices of teachers, though with limited success (Cohen 1988 (a); Cuban 1992; Cuban 1993; Ball and Cohen 1996). One of the primary lures of curriculum materials is that, of all the different instruments for conveying educational policies, they exert perhaps the most direct influence on the tasks that teachers actually *do* with their students each day in the classroom. One of the most often cited reasons for the failure of curricular reforms is the resistance of existing practices to change, coupled with the likelihood that practitioners will “mutate” the core aims of the reform to take on the very characteristics the reforms seek to change. Looking for the impact of such materials on instructional practice, many researchers have instead noted that it is the *materials* themselves that wind up changing while local practices remain unaffected (Welch 1979; Cohen 1988 (b); Cohen 1990; Dow 1991; Cuban 1992; Cuban 1993; Ball and Cohen 1996; Brown and Campione 1996).

Explanations for the continual disappointments of curriculum based reforms abound, focusing on the resiliency of teacher beliefs (Cohen 1990; Spillane 1999), conflicts between government policies and the realities of local instruction (Spillane 1998) and the inadequacies of professional development and teacher support (Wilson and Berne 1999; Putnam and Borko 2000). Implicit in many of these studies is the view that a fundamental gap exists between innovative designs for learning and teachers' capacities to put them into practice.

Recent efforts have sought to understand the complicated relationship between curriculum materials and instructional practice by examining the ways that teachers plan, use, adapt, and learn from curriculum materials (e.g. Remillard 2000; Sherin and Drake under review (a)). Much of this work echoes a key question posed by Ball and Cohen (1996): “What is — or might be — the role of curriculum materials in teacher learning and instructional reform?” Few of these studies, however, have examined the specific ways in which features and design strategies in curriculum materials influence instructional practice or proposed design strategies for producing “educative” curriculum materials.

This study adds to the current body of research exploring teachers' use of curriculum materials, but takes a different path to understanding this interaction by framing how teachers appropriate and mobilize instructional resources as a *design process*. I argue that teachers' use of materials can be characterized as *design* in that use hinges fundamentally on a process of perception, interpretation, and coordination of

cognitive and physical affordances of the curricular resources—all in the process of crafting daily instruction. This process is rooted in a dynamic interaction between elements of the curriculum materials and teachers’ knowledge, goals, and beliefs. Furthermore, I demonstrate how characterizing what teachers do with materials as *design* can provide important insights for the development of materials and professional development initiatives that better facilitate this teacher-tool partnership.

Framing the challenge: Fidelity and Variation

Many curriculum reform efforts have sought to shape what students learn by limiting practitioner discretion over the curriculum (Welch 1979; Dow 1991) while others have enlisted practitioners in the development of locally relevant reforms (McLaughlin 1976; Elmore 1979; McLaughlin 1990). While the former extreme stresses *fidelity* to a common vision, the latter embraces the *variations* that arise from the unique conditions and circumstances of local contexts (Snyder, Bolin et al. 1992).

Each approach has its advantages and disadvantages. For example, “remote control” reforms afford efficient and widespread dissemination of ideas and retain strong links to the intended goals and to core principles. However, while the remote control method may be attractive to school boards under increasing accountability standards, critics note that reforms adopting a “one size fits all” approach are bound to encounter classroom-level resistance since they overlook the unique qualities of individual teachers, the diverse needs of students, and the high variability of classroom and school contexts. On the other hand, reforms that adopt the mutual adaptation method are more likely to yield locally relevant solutions and provide greater opportunity for transforming the attitudes and skills of local practitioners. However, critics have questioned the scalability of such efforts because they are labor intensive, require extensive practitioner commitment, are difficult to share across sites, and risk dilution of the core principles that make them innovative in the first place. Furthermore, teachers often lack required design expertise.

This study provides a perspective on these tensions by examining three teachers’ use of the Global Warming Project,¹ a 10 week, inquiry-based classroom science project that engages middle school students in global climate change issues. As a materials-supported curricular reform, the Global Warming Project (GWP) embodies features of both the remote control and mutual adaptation approaches. On one hand, the GWP was developed through a collaborative partnership between university researchers (including the author of this study) and middle school teachers² that aimed to bridge the gap between research and practice. Thus, it exhibits many characteristics of the mutual adaptation approach. On the other hand, the curriculum materials that resulted from this development effort provided an instrument for spreading the innovation to teachers who were not part of the initial development effort and thus provided a mechanism for influencing classroom practice remotely. In these two ways, the GWP involves elements of both the mutual adaptation and remote control perspectives: while the ideas and practices in the GWP were crafted based on the needs and realities of local practitioners, the finished product embodied a set of core ideas and goals that the developers were interested in preserving at scale.

This tension highlights a role for materials that capture and communicate the goals and methods of the reform, as well as a role for locally situated, practitioner-driven design. From a materials development perspective, this dichotomy underscores the need to understand the ways that materials render and convey reforms as well as the ways that teachers interpret and appropriate (or resist) such resources within daily practice. This study provides a new way of thinking about the fidelity-variation tension by exploring

¹ Available at <www.letus.northwestern.edu/projects/gw>.

² This design partnership was part of the Center for Learning Technologies in Urban Schools (LeTUS), a collaboration involving researchers from Northwestern University and teachers from the Chicago Public Schools (additional LeTUS activities were coordinated with partners at the University of Michigan and Detroit Public schools).

teachers' use of curriculum materials from a design perspective. By examining the creative ways that teachers work with curriculum materials, this study illustrates the dynamics that in large part dictate how and why instructional reforms vary across contexts.

The Study: Understanding the intersection between teacher practice and the design of curricular innovations

The present study examines the intersection between teacher practice and the design of curricular innovations. I explored the ways that three urban middle school teachers interacted with the GWP materials, devoting particular attention to the nature of the curriculum designs and the ways that teachers used these resources to design instruction. The study involved multiple cycles of observation and analysis of classroom practice, based on qualitative investigation of classroom video, teacher interviews, and the curricular artifacts themselves.

At the heart of my approach is a belief that teacher practice is in many ways a design activity. In designing instruction, 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. Thus, rather than simply describing the personal and artifactual resources that teachers *have* during instruction, I aim to characterize *how* they mobilize such resources in order to accomplish their goals. This study provides several key contributions to understanding the intersection between teacher practice and the design of curricular innovations.

Characterizing practice.

Initial analyses of the three enactments revealed significant variation in how the teachers relied on the GWP materials, both within and across cases. In order to characterize these patterns in teacher use, I conducted a detailed analysis of one teacher's reliance on the GWP materials across a span of several activities. This analysis revealed a continuum that describes the different extents to which she relied on the materials in the performance of instructional tasks.

The analysis of one activity, the Sun's Rays Lab,³ illustrates three basic patterns of use. First, while the materials provided a detailed recipe that guides teachers and students through the steps of assembling the lab models, the teacher decided instead to engage her students in designing their own versions of the model. In this case, the teacher adopted the essential structure and format provided in the recipe, but rather than giving it to the students in the form of explicit instructions, she used it herself as a basis for informing her coaching of the students. Second, the materials provided instructions and sample work for a calculation to establish a quantitative pattern in intensity that mirrors the visible pattern. In this case, the teacher relied on the lesson plan verbatim to lead students through each step of the calculation. Third, the materials provide support for a discussion that helps students connect the features of their lab models to the actual phenomena they represent. During this exchange, the teacher seized upon a disagreement between two students to instigate a multi-day debate on competing interpretations of the model—a complete departure from the original design that nonetheless achieved similar goals.

These and other examples suggest a scale that characterizes the different extents to which the teacher *offloaded, adapted, or improvised* with the materials in the performance of instructional tasks. These three

³ The Sun's Rays Lab provides an investigation of how the angle of incidence at which sunlight reaches Earth's surface impacts the intensity of the light—and thus the energy—it receives. Students use pen lights and graph paper to model the Earth-sun relationship, measuring the areas cast by the light at different angles of incidence. With this data, students extrapolate the diminishing intensity that occurs as the light “spreads” over larger areas. For a more detailed explanation of this activity, see Sherin, Edelson & Brown (2000).

types of use describe the differential degrees in which responsibility for guiding instructional activity can be distributed between the teacher and available instructional resources. These degrees of distribution lie along a spectrum. At one extreme, the teacher *offloaded* responsibility for guiding instructional activity onto the materials. In these cases, she relied on the materials to support aspects of instruction. At the other extreme, she *improvised* her own strategies for instruction with minimal reliance on the materials. In between, she frequently *adapted* the curriculum resources in ways that reflected contributions of both the materials and personal resources.

Describing factors that influence practice.

In order to understand the factors contributing to each type of use, I developed a framework that integrates tandem analysis of both the curriculum resources and the teacher resources that contribute to each encounter. In doing this, I described the different facets of the GWP materials and analyzed how they constrained and afforded different each type of use. Furthermore, for each case, I described relevant aspects of each teacher’s knowledge, goals, and beliefs and analyzed how these constrained and afforded how they each perceived and mobilized the available resources in accomplishing curricular goals.

This approach yielded the *Design Capacity for Enactment* framework (DCE), which supports the integrated study of artifacts and their use by practitioners. It provides a means of identifying and situating the features of curriculum resources and teacher resources that influence the dynamics of curriculum implementation, and of characterizing the outcomes of these interactions at the level of instructional tasks (see Figure 1). The framework integrates analysis of curriculum resources in light of literature on the mediating role of artifacts (Wartofsky 1973; Wertsch 1991; Cole 1996; Wertsch 1998) and teacher resources in terms of the subject matter knowledge, pedagogical content knowledge, and commitments that influence teacher capacity.

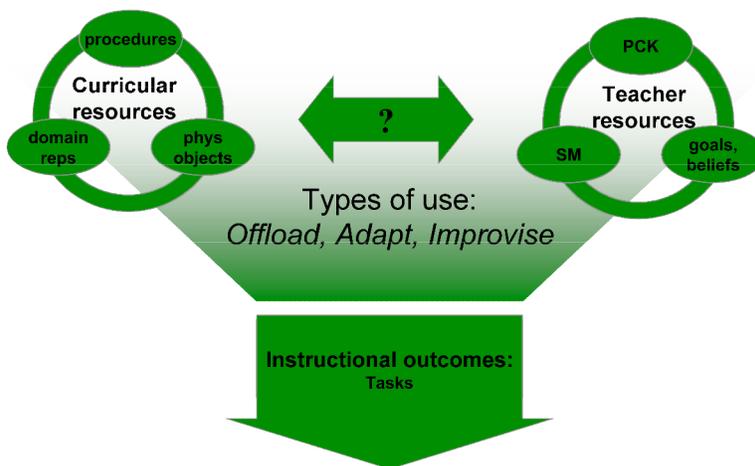


Figure 1: The Design Capacity for Enactment framework

In the framework, “curricular resources” entail representations of tasks, domain concepts, and physical objects. In the GWP, these elements of the design took the form of procedures, domain representations, and blueprints for configuring lesson materials, respectively. For instance, the Sun’s Rays Lab involved an explicit procedure for conducting the lab, a preferred representation for the Earth-sun relationship as depicted in the model, and a blueprint for setting up the penlight model. Each of these features played a key role in supporting and constraining different forms of classroom activity. In the adaptation example given in the previous section, the lab procedure provided the teacher with a basic framework for conducting the lab. Though she decided not to distribute the procedure to her students, it provided a basic

structure that helped her to guide the students in ways that met the intended goals. Similar patterns occurred with the representations of domain concepts and physical objects that were provided in the materials.

The nature of the teacher's own resources also played a key role in affording and constraining use of the curricular resources. The ways that she perceived and used the GWP was a function of her knowledge, skills, and commitments. For instance, in the adaptation example provided above, the teacher's understanding of the subject matter, her familiarity with the experimental design process, her ability to use her knowledge to coach students through the design process, and her desire to foster open-ended investigation all contributed to the particular ways in which she adapted the original procedure. Because of her familiarity with models and her experience in teaching students how to use them, she was able to perceive in the original design an opportunity for a model design task and at the same time was able to recognize the key features of the original model that needed to be preserved in order to meet the intended goals. Other teachers interpreted and used these features differently in light of their different knowledge, skills, and desires.

This method of analysis was applied to other instances where the teacher adapted, offloaded or improvised with the materials. Subsequently, I applied this framework to two additional cases of teachers' use of the GWP. While I will not describe these analyses here, the following section highlights the findings and implications that emerged from cross-case comparisons using the DCE.

Explaining variations in practice

The analysis described above helps to explain how and why teachers enter into different uses of the GWP materials by highlighting the situated interactions that characterize and influence the design of instruction. It suggests that teachers make constant decisions about how to use materials in the course of practice in light of classroom needs, curricular goals, and available resources. It also suggests that curricular materials themselves can provide important support by affording and constraining instruction.

Individual Capacity.

Variations in each teachers' use of the GWP materials suggest the importance of *pedagogical design capacity*—teachers' capacity to perceive and mobilize existing resources in order to craft instructional contexts. This theoretical construct emanates from a vision of instructional capacity as not just as a function of the knowledge that teachers have, but as their ability to accomplish new things with that knowledge (Ball & Cohen, 1999)—a distinction akin to what Gilbert Ryle (1984) referred to as knowledge *that* versus knowledge *how*. Just as Wertsch (1998) discussed agents' "skills in using mediational means," and Pea (1993) described the "situated invention of uses" by which actors draw upon cognitive tools, I mean to highlight the creative and constructive dimensions of teachers' instructional capacities.

Pedagogical design capacity (PDC) provides a way of evaluating how individual teachers perceive and mobilize the instructional resources described by the *Design Capacity for Enactment* framework. While the framework provides a means for describing the resources that influence teachers' use of materials, pedagogical design capacity characterizes their skill in interpreting and working with such resources. In other words, while the DCE framework accounts for the "what" of instructional capacity—that is, the subject matter knowledge, pedagogical content knowledge, goals, and beliefs that influence practice—PDC describes "how" such facets are used.

By focusing on the processes by which teachers employed curricular resources, PDC accounts for similarities in teacher practice in the face of differences in resources and outcomes. While the products of teachers' instructional designs looked very different, their ways of generating such outcomes shared

important similarities. For instance, while teachers with different knowledge, skills, and commitments emphasized different aspects of the curriculum design (thus producing different instructional outcomes) it is possible that they engaged in similar processes of curricular adaptation, offloading, or improvisation.

PDC accounts for the fact that the two “experienced” teachers in the study both engaged in extensive adaptations and improvisations of the GWP while retaining the core aims of the project. While the differences in their specific outcomes can be explained by variations in the nature of their knowledge, instructional goals, and beliefs, common degrees of PDC are evident in the similar patterns by which the teachers harnessed their individual capacities in the perception and mobilization of available resources. In other words, both teachers relied on existing knowledge, skills, and commitments as they interpreted and used the GWP—and while the specific nature of such personal resources varied, the ways that such resources contributed to curriculum use were similar.

PDC also accounts for differences in teacher practice in the face of similar resources. For example, one comparison of an instructional sequence revealed that two teachers exhibited very similar subject matter and pedagogical content knowledge, yet possessed very different capacities to mobilize this knowledge in using the GWP. In this comparison, the DCE framework highlighted common teacher resources and curriculum resources in each case, whereas an analysis of the patterns by which they perceived and mobilized the GWP revealed different degrees of individual PDC.

The DCE framework provides a means of identifying the various factors at play in teachers’ curriculum use, as well as patterns such use. These patterns, in turn, can be used to draw comparisons with teachers in different instructional contexts. Such patterns may highlight similarities or differences in practice that transcend the specific and situated features of each case, capturing commonalities or variations in how teachers approach the use of materials. The notion of PDC provides a lens for comparing the patterns in each application of the DCE across cases.

Capacity of the teacher-tool partnership.

The analysis also suggests that the ways in which teachers perceive and mobilize curriculum materials is highly influenced by the nature of the designs themselves. This points to a dynamic interplay between teachers and materials in which capacity can be seen to be a function of the teacher-tool partnership. This systemic perspective provides a means of evaluating pedagogical design capacity in terms of the situated interactions that occur among systems of resources during instruction. My examination of one teacher’s use of the GWP materials, for example, revealed the various ways that teacher resources and curriculum resources interacted in order to produce unique, highly situated instructional outcomes. While these outcomes were highly dependent on the teacher’s individual capacity, it is also clear that the nature of the designs had a profound impact on instruction.

This points to a systemic relationship between the teacher’s own knowledge, skills, and commitments and the explicitness with which the materials represent the intended concepts, strategies, and rationales of the designers. Where the designs were explicit and robust, the teacher either relied on them extensively (in cases where she possessed limited knowledge and skill with respect to the relevant content) or adapted them significantly (in cases where she possessed robust knowledge and skill with respect to the content). The decision to adapt or adopt was a function of both the degree of alignment between the teacher’s goals and designers goals, as well as the quality of the materials in representing the necessary concepts, tasks, and purposes of the activity in ways that were intelligible to the teacher.

Implications for teacher practice

The study provides important implications for how teachers are prepared, how they are matched with appropriate materials, and how their enactments are evaluated. First, these findings have implications for

teacher preparation and professional development. In addition to support in learning subject matter and ways of teaching the content, teachers also require support in finding ways to interpret the affordances of curricular resources and to craft appropriate uses for them. Thus, teacher preparation and professional development might explicitly target the design skills required for effective use of instructional materials. Second, these findings have implications for matching curricular materials to teachers. Different teachers might require different types of materials. For example, teachers with robust capacity to perceive underlying curricular goals might prefer open-ended resources which can be configured in different ways according to local circumstances, whereas teachers with less of such capacity might require materials that provide more explicit pointers to the uses and rationales of such resources, as well as more specified paths for putting them to use. The “one size fits all” approach to curriculum design fails to appreciate the fact that teachers with different pedagogical design capacities might require different levels of articulation. Finally, these findings have implications for the ways that we evaluate teacher practice. In addition to evaluating instructional capacity based on inputs and outputs— that is, the factors that influence instruction and the products of instruction— evaluators might also consider the processes by which teachers perceive and mobilize available resources to create local instructional solutions. Such an approach would value the craft-oriented aspects of teaching and might provide a means for comparing teachers despite diverse backgrounds and professional contexts.

Implications for the design of curriculum materials

My analysis also suggests design guidelines for producing materials that support the sort of teacher-tool partnership described in this study. First, materials should not only provide resources for instruction, but should also support teaching as a design process. Rather than depicting instruction as prefabricated procedures, lesson plans should support the processes by which teachers consider key goals, relevant content, appropriate strategies, and available materials. Such design process documents might provide a key entry point for larger databases of additional resources, such as domain representations, pedagogical strategies, and configurations of physical tools. Second, curricular materials should accommodate the process of local customization. Given that prefabricated, procedure-driven lesson plans are frequently dismantled in order to meet local needs, curricular resources should be crafted in ways that support teachers in selecting appropriate resources for each situation. Finally, curricular materials should differentially support teachers with varying background experiences and different instructional capacities. This study reveals that experienced teachers require less resolution and tend to favor open-ended resources, whereas less experienced teachers require more resolution and illustrative examples. Such teachers require different interfaces to the curricular resources. Furthermore, curriculum materials themselves frequently contain multiple layers of features— from underlying domain representations to examples of practice. Designers must find ways to depict these different types of resources and ways of expressing their instructional affordances, as well as find different ways of representing these resources to different types of teachers.

Designers might look for inspiration to the example of do-it-yourself home furnishing stores such as “The Container Store” and “Hold Everything.” Unlike stores which sell prefabricated storage solutions, these outlets provide users with modular, configurable resources which they assemble themselves in order to meet the particular needs and constraints of their own homes. Such retailers avoid prefabricated solutions, recognizing the value and necessity of local customization. Such stores face two primary design challenges. First, they must craft modular resources in ways that communicate key affordances and constrain activity in meaningful ways. Second, they must provide support for customers, in the form of illustrative examples of use and, perhaps, coaches who guide less experienced customers through a process of considering their goals, identifying key features of their local contexts, and then configuring available resources in ways that address them.

A significant limitation of previous studies of the teacher-material encounter is their insufficient treatment of the nature of curriculum designs and the role of designed artifacts in shaping activity. In bringing a design perspective to the study of curriculum implementation, I have introduced a scale for characterizing teachers' differing degrees of reliance on the materials, a framework for analyzing the factors that influence teacher-tool interactions, and a theoretical perspective that characterizes differences both in teachers' individual capacities to use materials and in the overall systemic capacities of the teacher-tool partnerships. This work attempts to bring research on the mediating role of artifacts to bear on questions of teacher practice and curriculum implementation. This integrated outlook emphasizes the activity—or design process—by which teachers bring designed artifacts to bear on instruction.

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