

CHAPTER 10

Revisiting the Connection between Research and Practice Using Formative and Design Experiments

Barbara A. Bradley

David Reinking

There has always been a great divide between education research and practice.

—COLLINS (1999, p. 289)

Education is not in need of research to find out how it works. It is in need of creative invention to make it work better.

—EBEL (1982, p. 18)

We welcome this opportunity to update a chapter that we wrote for the first edition of this book. An update is clearly justifiable because, as would be expected for a relatively new and evolving approach to research, there are important new developments to report. For example, much more has been published about what is now often referred to generically as design research or design-based research. Most notably, there are now two edited books about design research (Kelly, Lesh, & Baek, 2008; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006) and another that explicates formative and design experiments in relation to language and literacy research (Reinking & Bradley, 2008). Furthermore, beyond the themed issue in *Educational Researcher* (Kelly, 2003) that we drew upon in our former chapter, two other respected research journals have devoted issues to this approach: *Educational Psychologist* (Sandoval & Bell, 2004) and the *Journal of the Learning Sciences* (Barab & Squire, 2004).

Paralleling this increased attention, more literacy researchers are conducting research guided by the principles and perspectives of design, and

they are publishing their results in a variety of outlets (e.g., Baumann, Ware, & Edwards, 2007; Boling, 2008; Bradley & Reinking, in press; Fisher, Frey, & Lapp, 2009; Ivey & Broaddus, 2007; Massey, 2007; McKenney & Voogt, 2009; Taboada & Rutherford, in press). Furthermore, and significantly, the U.S. government has changed its views on educational research and is now calling for studies that involve more authentic collaborations among practitioners, researchers, and policymakers, which is more consistent with design research. Funding agencies, such as the Institute of Education Sciences, are emphasizing educational research that focuses on process, not simply outcomes (Viadero, 2009). For example, the rationale for goal 2 under many of the multi-goal-structured funding programs through the U.S. Department of Education, including literacy research, states, "To develop or improve education interventions requires an iterative process of designing, testing, revising, and testing to produce a product or system that functions in the way that the developer intends for it to function and that can be implemented in actual education delivery settings (e.g., schools)."

Despite these new developments, the central rationale and guiding questions that underlie formative and design experiments, as we first wrote about them, remain unchanged. That is, how can and how should literacy research inform instructional practice? How can the long-lamented gap between research and practice be closed? Furthermore, the primary reasons why educational researchers have gravitated toward this approach have remained unchanged. Specifically, educational researchers are often attracted to this approach because they are dissatisfied with more established and widely used experimental or naturalistic methodologies. The warrant for that dissatisfaction can be found in considering the long-standing gap between conventional research methodologies and instructional practice, which we highlighted in our original chapter.

For example, at the time we wrote this chapter for the first edition, the U.S. government was vigorously promoting the view that experimental methods should be the gold standard for implementing scientifically based reading instruction (National Reading Panel, 2000). Those who hold this view—and many researchers and policymakers still do—believe that practitioners should implement literacy instruction to be consistent with generalizations derived from carefully controlled experiments. They see the role of literacy research as a systematic winnowing to determine which among many alternative instructional interventions or approaches work best on average. What works best is typically defined narrowly as instruction that results in statistically superior student achievement based on quantifiable measures. Determining what works best on average to promote educational achievement is useful information, but it does not inherently provide guidance about what factors might be relevant to successful implementation in a particular context. Focusing on tournament-style research to see which instructional interventions are left standing after experimental comparisons also promotes misguided notions such as best practice, which is an

unattainable goal in any absolute sense and likewise devalues professional judgment (Reinking, 2007).

Researchers who employ naturalistic methodologies, on the other hand, also generate useful information but of a different kind. Because such methodologies are suited to a deep examination of particular instructional contexts, they produce data that are perhaps more useful in helping practitioners understand the complexities and subtleties of instructional practice. When studying classroom instruction, these researchers often aim to reveal aspects of instructional practice that might otherwise go unnoticed by practitioners or that might help them better understand and reflect on their practice. Strong generalizations about practice or conclusions about best methods are not typically the goal of such studies, although they may be guided by and interpreted in light of pedagogical theories, educational philosophies, or ideologies designed to provide a broad frame for instruction. The topics investigated typically are not related to conventional measures of achievement but, instead, tend to focus on dimensions of literacy such as developing motivation to read, acquiring personal agency through texts, and promoting sociocultural awareness. However, studies using naturalistic methods rarely provide explicit guidance that directly informs practitioners.

For many researchers, the best of all worlds remains one in which these two broad methodological options would be complementary, perhaps creating a synergy that would guide teachers and improve instructional practice toward realizing a wide range of valued goals for literacy instruction. However, that has rarely happened, and researchers often remain inside their methodological silos with little dialogue or synthesis. We have seen no significant movement that brings these two research traditions closer together since we wrote our chapter for the previous edition. Neither have we seen any new evidence that experimental or naturalistic approaches have begun to influence directly and pervasively instructional practice. The conclusions drawn about the failures of education research to influence practice by writers we cited in our early version of this chapter still hold (e.g., Collins, 1999; Eisenhart & Borko, 1993; Labaree, 1998; Lagemann, 2000). In fact, to that list we could add work that has been published more recently such as Pressley, Graham, and Harris (2006) in the area of literacy and more general commentaries on education research, such as Barab and Squire (2004), Hoadley (2004), Hostetler (2005), Lewis, Perry, and Murata (2006), and Reeves (2006). And although we have become aware of some evidence that the academic reward structure at some institutions is shifting slightly toward acknowledging the value of making tangible improvements in practice, the following quote from Eisenhart and Borko (1993) still seems current: "Researchers see the significance of research in terms of its implications for understanding far-ranging repercussions, predicting and improving the future, information policy, or getting tenure, whereas teachers usually want research results to bear directly on their classroom prac-

sense and likewise devalues professional naturalistic methodologies, on the other hand, but of a different kind. Because such an examination of particular instructional practices and subtleties of instructional practice, these researchers often aim to help them better understand and reflect on their practice that might otherwise go unnoticed. The goal of such studies, although they may be informed by pedagogical theories, educational research, and are perhaps more useful in helping practitioners and subtleties of instructional practice, these researchers often aim to help them better understand and reflect on their practice that might otherwise go unnoticed. The goal of such studies, although they may be informed by pedagogical theories, educational research, and are perhaps more useful in helping practitioners and subtleties of instructional practice, these researchers often aim to help them better understand and reflect on their practice that might otherwise go unnoticed.

of all worlds remains one in which these two approaches would be complementary, perhaps creating a synthesis of valued goals for literacy instruction. In the earlier version of this chapter still hold true, and researchers often remain inside their respective traditions with little dialogue or synthesis. We have seen these two research traditions closer together for the previous edition. Neither have experimental or naturalistic approaches been as pervasive in instructional practice. The challenges of education research to influence practice and pervasively instructional practice. The challenges of education research to influence practice and pervasively instructional practice. The challenges of education research to influence practice and pervasively instructional practice.

practice" (p. 79). To graphically illustrate the disconnection between research and practice, consider the printed program for the annual meeting of the American Educational Research Association. Each year it is the size of the phone book for a major city. Yet it is unclear what specific advances the research reported has made each year toward directly informing practitioners about how they can improve education practice.

Thus, we continue to believe that the gap between research and practice remains wide and that literacy researchers still need to refocus their methodological emphases to address specifically how promising instructional interventions might be implemented in classrooms to achieve valued pedagogical goals (see Dillon, O'Brien, & Heilman, 2000). We continue to need methodologies that acknowledge the complexities of classroom teaching and that align with the day-to-day management of that complexity. We continue to need approaches that enlighten practitioners about research-based pedagogies to enhance literacy but also provide them with specific insights about how they might effectively implement instructional interventions. More than ever, we believe, design research has the potential to narrow the gap between research and practice and can contribute to synthesizing in action the work of researchers who hold diverse methodological perspectives (McCandliss, Kachman, & Bryant, 2003). In the remainder of this chapter, we revisit and update our earlier explication of formative and design experiments in light of new developments and our new personal understandings of this approach and its use in literacy research.

WHAT ARE FORMATIVE EXPERIMENTS AND DESIGN EXPERIMENTS?

Classroom life, in my judgment, is too complex an affair to be viewed or talked about from any single perspective.

—JACKSON (1990, pp. xxi–xxii)

An Update on Terminology

In the earlier version of this chapter, we referred to studies using this approach as formative or design experiments. These terms can be traced to the earliest roots of this approach, as explained in a subsequent section of this chapter. These terms continue to be used. Literacy researchers, in particular, for reasons that are not clear, seem to prefer the term *formative experiment*. For example, to our earlier citations of literacy research using this terminology (Jiménez, 1997; Lenski, 2001; Reinking & Watkins, 2000; Neuman, 1999) we can add Baumann and colleagues (2007), Bradley and Reinking (in press), Fisher and colleagues (2009), Ivey and Broadus (2007), Massey (2007), and Taboada and Ruhterford (in press). Researchers in other content areas such as mathematics education or instructional technology tend to prefer the term *design experiments* (e.g., Cobb, Confrey,

diSessa, Lehrer, & Schauble, 2003), as do those invested in more conventional experimental approaches and in creating a science of design (e.g., see Kelly et al., 2008; van den Akker et al., 2006). However, perhaps because of uncertainty about distinctions among these different terms and because there have been somewhat different emphases around some core attributes of this approach, there is a trend toward using broader, more encompassing terms such as *design research* or *design-based research*. Thus, for the remainder of this chapter, we use the term *formative experiments* to refer to how this approach has been understood and used, particularly among literacy researchers, and the term *design research* as a generic, more encompassing term that refers to a variety of terms and emphases among a broader range of education research that all share a core of defining attributes (see later section on defining methodological characteristics).

What Design Research Does That Other Approaches Typically Do Not

The study of how educational interventions work can never be far removed from the task of engineering them to work better.

—NEWMAN, GRIFFIN, AND COLE (1989, p. 147)

Educational research often sits in the uneasy intersection between science and engineering.

—FEUER, TOWNE, AND SHAVELSON (2002, p. 28)

Design research in general and formative experiments in particular fill a neglected gap in research aimed at guiding instruction because they address more directly the questions and issues that practitioners face and that are not addressed as authentically or as directly by other research methodologies. That is, scientific experiments comparing the effectiveness of alternative instructional interventions may provide useful generalizations across diverse contexts. However, scientific experiments, of necessity, can focus only on relatively few variables, and they assume that other potentially influential variables have random effects. The wide range of variation that is inherent in classrooms and schools, which can often have important influences on the effectiveness of an intervention, cannot be studied in a single conventional experiment. Furthermore, for experimental research to be valid, an instructional intervention must be implemented in a standard fashion, not adapted to unique or changing conditions (see Reinking & Pickle, 1993, for an example of how this is problematic). As we have argued elsewhere (Reinking & Bradley, 2008), this requirement that interventions be implemented with fidelity is the antithesis of formative experiments and design research. Formative experiments and design research aim to identify and understand any salient factors that enhance or inhibit an intervention's effectiveness while it is being implemented and then to modify or adapt the

), as do those invested in more conventional research in creating a science of design (e.g., see Schön et al., 2006). However, perhaps because of the differences among these different terms and because of the different emphases around some core attributes, the term *design-based research* or *design-based research*. Thus, for the term *formative experiments* to refer to a specific type of research, it must be understood and used, particularly among those who use the term *design research* as a generic, more encompassing term and emphases among a broader group of terms and emphases (see Schön et al. for a share of defining attributes (see Schön et al. for logical characteristics).

Other Approaches Typically

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Formative experiments in particular fill a niche in guiding instruction because they address the issues that practitioners face and that are not addressed directly by other research methodologies. Comparing the effectiveness of alternative instructional approaches provide useful generalizations across instructional experiments, of necessity, can focus on specific aspects and they assume that other potentially important effects. The wide range of variation that exists in instructional approaches, which can often have important implications for an intervention, cannot be studied in a laboratory. Furthermore, for experimental research to be useful, the intervention must be implemented in a standard way under changing conditions (see Reinking & Smith, 2008, for this is problematic). As we have argued (Schön et al., 2008), this requirement that interventions be standardized is antithetical to formative experiments and design research aim to identify factors that enhance or inhibit an intervention's effectiveness and then to modify or adapt the

intervention based on that analysis. Ignoring the panoply of variables that are continually fluctuating in classrooms, or assuming that they are random factors and failing to adapt instruction to those variables, is contrary to the essence of effective teaching. Naturalistic studies, on the other hand, may document the complexity and subtleties of implementing an intervention, but they do not typically address how that complexity might be managed by a practitioner working to accomplish specific pedagogical goals. Formative experiments and design research, unlike experimental or naturalistic studies of instructional interventions, thus, accommodate both the variation inherent in classrooms and the need to adapt interventions in response to relevant variation.

To simplify for the sake of comparison, a controlled experiment might ask: "Which intervention is better on average, X or Y?" (What is best?) A naturalistic study might ask: "When implementing intervention X (or Y), what happens?" (What is?) Design research, on the other hand, is better suited for the following type of question: "Given that intervention X (or pedagogical theory Y) shows promise to bring about a valued pedagogical goal, how can it be implemented to accomplish that goal?" (What could be?) Other key questions are important to understanding design research in general and formative experiments in particular: for example, What factors enhance or inhibit an intervention's effectiveness in moving toward the pedagogical goal? How might the intervention or its implementation be modified, in light of these factors, to be more effective? It is these latter two questions that make a formative experiment formative. That is, formative experiments, like design research in general, entail an iterative process of data collection to determine what is or is not working, followed by carefully reasoned modifications, as needed, to enhance the effectiveness of the intervention. In short, the primary focus is to achieve a pedagogical goal, which is accomplished by recognizing the complexity of the instructional environment and making adaptations or modification to the environment or the intervention, as needed.

Formative experiments, and design research in general, are also experiments but in a sense broader than the formal hypothesis testing that guides a conventional, rigorously controlled conventional experiment. Schön (1987), in his seminal book on reflective practice, argued that several forms of experimentation are useful and that three forms are used simultaneously by reflective practitioners: (1) *exploratory experimentation*, which is action just to see what happens; (2) *move-testing experimentation*, which is aimed at determining whether an action is affirmed or negated toward a desired end and noting any unintended consequences; and (3) *hypothesis testing*, which is formal experimentation to see whether alternative hypotheses are affirmed or negated. Design research employs all three types of experimentation, just as reflective teachers do, but also entails a more systematic record of this experimentation and typically includes collegial discussions and overt reflections based on careful data collection. Thus, design research,

because it addresses questions clearly relevant to practitioners and employs forms of experimentation similar to what practitioners use, is more directly related to practice than are other forms of research and is, therefore, more likely to appeal to practitioners. A further advantage of formative experiments, and design research in general, when compared with more conventional research methodologies is that they draw on and acknowledge the importance of intuitive professional knowledge, incorporating that knowledge within a systematic framework for practice-oriented research.

Formative experiments and other approaches to design research may be particularly appealing to practitioners because they mimic the process of effective teaching, and they facilitate a collaborative relationship with researchers grounded in authentic practice. However, this collaboration does not necessarily mean that practitioners and researchers share equal roles and responsibilities for conducting the research and need not be collaborative research in the strictest sense. Rather, we believe that design research aligns well with what Cole and Knowles's (1993) described as a teacher development partnership. Specifically, they stated,

True collaboration is more likely to result when the aim is *not* for *equal* involvement in all aspects of the research; but, rather, for *negotiated and mutually agreed upon* involvement where strengths and available time commitments to process are honored. (p. 486)

In addition to developing a professionally productive relationship with practitioners, researchers rely on a practitioners' knowledge and expertise to assist in the identification of factors that can enhance or inhibit an instructional intervention's effectiveness and the development of realistic adaptations that might be made to the intervention and the classroom environment.

Engineering is a useful analogy for conceptualizing this approach in relation to other education research methodologies, and here the term *design experiment* might be more apt. Engineers make use of theoretical and empirical research to design something of functional utility. Their work builds bridges (sometimes literally) between theory, research, and practical application. But workability in the real world is the essence of their work, where occasionally relevant variables only emerge in real-world applications that go beyond purely theoretical or laboratory-centered research. Wind tunnels are clearly useful in designing airplanes consistent with the principles of aerodynamics, but wind tunnels do not readily simulate the sustained wear some parts experience during thousands of hours of flying under extremely different conditions. Furthermore, the work of engineers in designing practical application can sometimes clarify or stimulate the need for more theoretical and laboratory investigations. In fact, Stokes (1997) has argued that often the most important theoretical concepts in science emerge when scientists focus their attention on achieving practi-

ly relevant to practitioners and employs what practitioners use, is more directly forms of research and is, therefore, more further advantage of formative experiential, when compared with more conventional, that they draw on and acknowledge the practical knowledge, incorporating that knowledge for practice-oriented research.

Other approaches to design research may be used by practitioners because they mimic the process that facilitate a collaborative relationship with practice. However, this collaboration between practitioners and researchers share equal responsibility for the research and need not be collaborative in sense. Rather, we believe that design research, as Gole and Knowles's (1993) described as a design process, specifically, they stated,

...to result when the aim is *not* for *equal* involvement; but, rather, for *negotiated and mutually beneficial* strengths and available time commitments to

...a professionally productive relationship with practitioners' knowledge and experience of factors that can enhance or inhibit an intervention and the development of realistic goals for the intervention and the classroom environment.

...ology for conceptualizing this approach to research methodologies, and here the term *design* is apt. Engineers make use of theoretical knowledge of something of functional utility. Their work is a balance between theory, research, and practical application. The real world is the essence of their work, and solutions only emerge in real-world applications. Unlike theoretical or laboratory-centered research, design research, such as designing airplanes consistent with the needs of the world and tunnels do not readily simulate the conditions during thousands of hours of flying. Furthermore, the work of engineers can sometimes clarify or stimulate the results of laboratory investigations. In fact, Stokes (1993) has argued that the most important theoretical concepts in engineering are those that focus their attention on achieving practi-

cal goals. He highlights Louis Pasteur's work aimed at seeking ways to preserve food, which led to the field of microbiology, as a classic example of how the distinction between basic and applied research can be an unfortunate dichotomy.

Likewise, knowledge of what has or has not worked under a variety of practical conditions allows engineers and mechanics to acquire useful intuitive knowledge that may lead them occasionally to work outside or beyond accepted theory and research. Duffy (1994) has acknowledged that such intuitive knowledge is necessary for teaching. He stated, "Viewing research findings as something to be handed down as technical information ignores the reality that teachers must make strategic decisions about when to apply findings, how to adapt them to certain situations and even when it might be appropriate to ignore the findings altogether" (p. 19). Thus, formative experiments and design research value and systematically identify how the intuitive knowledge of experienced practitioners might elucidate and refine, and perhaps occasionally negate, the findings generated by other research methodologies. In that sense, this approach focuses on what has been referred to as conditional knowledge (Paris, Lipson, & Wixson, 1983) and the knowledge that is necessary to be a successful practitioner in ill-structured domains such as teaching (Spiro, Feltovich, Jacobson, & Coulson, 1992).

Furthermore, Hargreaves and Stone-Johnson (2009) have suggested that the evidence useful to teachers must take into account the multilayered dimensions of teaching, including the technical, intellectual, experiential, emotional, moral, ethical, political, situated, and cultural aspects of their individual practice. Formative experiments, in particular, as they have been used in literacy research, do not overlook or underestimate practitioners' perspectives in these areas when implementing an intervention and in accounting for its success, or the lack thereof, in accomplishing a goal. Teachers' beliefs about teaching are one domain into which an intervention needs to be integrated and sometimes negotiated and adapted. Similarly, Reigeluth, and Frick (1999) have pointed out that most research of instructional interventions has focused almost exclusively on effectiveness, most often in relation to measurable academic achievement. However, relatively few have focused on efficiency (e.g., whether an intervention is economically feasible and logistically practical) or on appeal (e.g., whether teachers and students find an instructional intervention engaging, and whether teachers will use it after the researcher leaves the classroom). Finally, as discussed further in subsequent sections of this chapter, formative experiments, as we have conducted them in our own work, are driven by a clearly articulated instructional goal that must be explicitly justified as worthy and important. Thus, this approach encourages researchers not only to address explicitly a specific pedagogical goal but also to position their work explicitly in terms of the goal's pedagogical value. In other approaches to classroom research, the pedagogical goal and its value are

often assumed or implicit. For example, what are the short- and long-term goals of an intervention such as Readers' Theatre and, more importantly, why are those goals important?

Thus, design research is grounded in an engineering metaphor instead of the laboratory or the lens metaphors that ground conventional scientific experiments or naturalistic inquiry. More literally, Sloane and Gorard (2003) have raised the question of whether education research should be conceptualized primarily as an engineering science rather than a social science. Going further, Reeves (2006) has even suggested that such an orientation is the only socially responsible approach to education research. Ecology is another apt metaphor because in this approach classrooms are acknowledged to be complex environments with multiple layers of interacting variables and where changing one variable often affects many others. In fact, ecology is a metaphor that is employed in conventional scientific experiments, which are often judged on how well they balance an inherent tension between experimental and ecological validity. However, in design research that tension does not exist because data collection and analyses are driven by ecological validity. Another type of validity that is more central to this approach is consequential validity (Messick, 1992). By identifying specific goals and explicitly justifying their importance, researchers who conduct design research are clearly focused on the authentic pedagogical, not just the theoretical, consequences of their work.

ORIGINS AND HISTORICAL ROOTS

Ignorance is a better starting place than truth for assessing the usefulness of educational research . . . some research projects are of little use to researchers or practitioners even though they reflect our highest ideals of truthfulness in data collection and analysis.

—WAGNER (1993, p. 15)

Tracing the origin of design research is akin to identifying the headwaters of a river. There seems to be no single, clearly identifiable source for this approach. Instead, formative experiments have emerged from and been supported by the ideas of diverse researchers and writers in the late 1980s and early 1990s who shared a dissatisfaction with experimental methods as a means for informing instructional practice. On one hand, some researchers, such as Moll and Diaz (1987), who have a more sociocultural viewpoint and who gravitated toward qualitative methods, saw improving education as the critical goal of educational research, and they saw the limitations of conventional scientific experiments in reaching that goal. Others, such as Bruce and Rubin (1993), argued for what they called "situated evaluation," which emerged from their insight that teachers did not necessarily implement innovative instructional interventions—in this case a computer-based intervention to enhance purposeful reading and writing—in ways consis-

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tent with the intent of the developers. Other researchers invested in finding insights about learning using conventional experiments saw the limitations of trying to move their findings from the laboratory to classrooms. Most prominent of the researchers in that category is Ann Brown, highly regarded for her work related to metacognition and reading. In an often-cited article pointing to the origins of design research, Brown (1992) described her own turn as a classical theorist and laboratory-oriented researcher to *design experiments*, a term she attributed to Collins (1992). Brown stated, "As a design scientist in my field, I attempt to engineer innovative educational environments and simultaneously conduct experimental studies on those innovations" (p. 141).

Jacob (1992), who discussed what she called formative experiments in her chapter in the *Handbook of Qualitative Research in Education*, traced their roots to neo-Vygotskian scholars (e.g., Davydov, 1988) and to cognitive psychologists interested in the social construction of psychological tasks. Newman and colleagues (1989) articulated some of the tenets of this view, and subsequently Newman (1990) used the term *formative experiment* to describe his study of how computer technology might be used to enhance scientific thinking among middle school students. This study was important because it was the first to outline and illustrate a specific methodological framework for conducting a formative experiment.

Since the mid-1990s, literacy researchers have conducted studies that fall into the general category of design research. An indication that formative experiments have entered the mainstream of literacy research is that several of these studies have been published in *Reading Research Quarterly*, a highly regarded outlet for literacy research (Ivey & Broaddus, 2007; Jiménez, 1997; Neuman, 1999; Reinking & Watkins, 2000). Contemporary with our own research using this methodology, we have attempted to articulate the basis and need for formative experiments and, more important, how this approach might be translated into specific methods for conducting a formative experiment (Baumann, Dillon, Shockley, Alvermann, & Reinking, 1996; Reinking & Bradley, 2008; Reinking & Pickle, 1993; Reinking & Watkins, 2000). For example, a framework for conceptualizing, conducting, and reporting formative experiments initially used by Reinking and Watkins (2000) and detailed subsequently in this chapter has informed several other investigations in literacy (Bradley & Reinking, in press; Fisher et al., 2009; Ivey & Broaddus, 2007; Lenski, 2001; Massey, 2007; Taboada & Rutherford, in press). Nonetheless, there are several other frameworks for conducting design research that might guide researchers who take this approach (e.g., Bannan-Ritland, 2003; Clements, 2009; Gravemeijer & Cobb, 2006; Reigeluth & Frick, 1999).

There is no agreed-upon epistemological foundation for design research, and perhaps none is needed if it is viewed basically as a design or engineering science. However, we believe that formative experiments and design research fit naturally with the philosophical tenets of pragmatism,

which has been associated with education and with education research since John Dewey and has been revived as a paradigm useful to education research in general (Cherryholmes, 1993) and to literacy research in particular (Dillon et al., 2000). Pragmatism seems especially well suited to the aims and methods of formative experiments. For example, it allows for more epistemological flexibility in method and analysis, focuses on useful ends, and encourages a democratic involvement of multiple stakeholders. Formative experiments and design research also naturally connect with mixed methods approaches to research, which have been linked epistemologically to pragmatism (Tashakkori & Teddlie, 1998, 2003).

DISTINGUISHING METHODOLOGICAL CHARACTERISTICS

Educational research is evolving; its designs and procedures are not cast in stone. Conscientious researchers are continually trying out new methods . . . to make their work stronger, more compelling, and more useful.

—EISENHART AND BORKO (1993, p. 11)

Researchers who consider their research to fall under the umbrella of design research have taken somewhat different approaches, adopting different terminology and conducting their research following different models with different emphases and different approaches to data collection and analyses. Nonetheless, there is a core of defining characteristics that unite this relatively new approach to education research and that distinguish it from other approaches. Furthermore, the absence of any of these characteristics within a particular study raises questions about its conceptual authenticity as an example of design research. Adapting and extending the work of Cobb and colleagues (2003), we believe that the following general characteristics define that common core:

1. *Theoretical*. Theory plays a predominant role in design research, but, unlike other approaches to classroom research, it is grounded more specifically in efforts to design effective, workable, and appealing instruction. A focus on theory also distinguishes design research from related data collection methodologies such as formative evaluation (Flagg, 1990) and rapid prototyping (Tripp & Bichelmeyer, 1990), which are efforts focused entirely on developing an instructional artifact, typically uninformed by theory. As with other research methodologies, theory in design research is used to justify the importance of the inquiry, to provide a rationale for the intervention, to interpret findings, to contextualize conclusions, and so forth. However, as Cobb and colleagues (2003) stated, the purpose of design experiments is “to develop a class of theories about both the *process* of learning and the *means* that are designed to support learn-

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ing." Furthermore, they stated that in developing theories "design experi-
 ments create conditions . . . [that] place these theories in harm's way" and
 that theory "must do real work" by being "*accountable to the activity
 of design*" (p. 10). According to Cobb and colleagues, these theories are
 humble and grounded in the local, not grand explanatory theories such as
 a general theory of motivation and learning that might be applied gener-
 ally to all learning contexts but that can be mitigated by other factors in
 particular contexts.

2. *Goal oriented.* Design research investigates how to improve edu-
 cation and learning in authentic instructional environments toward well-
 specified goals that are explicitly justified in relation to theory and practice.
 For example, researchers conducting formative experiments explicitly iden-
 tify and justify a goal, which is accompanied by a scholarly explanation of
 why it is worthy of investigation. Furthermore, that goal becomes a refer-
 ence point for collecting and analyzing data, for making modifications to
 the intervention and/or the instructional environment, and for determining
 the extent to which progress has been made.

3. *Intervention centered in authentic instructional contexts.* The cen-
 tral object of study in design research is an instructional intervention that
 is a mechanism for facilitating a pedagogical goal or sometimes to test
 a theory in the crucible of practice. The intervention may be innovative
 and aimed at addressing a problematic area of instruction, or it may be a
 well-known intervention that has been investigated extensively using other
 methodologies. It may be a well-defined instructional activity or a coher-
 ent set of activities, and it must be justified in terms of theory, any previ-
 ous empirical work that exists, and its promise for improving instructional
 practice. The intervention must also be studied in an authentic instruc-
 tional environment where variations are allowed to occur naturally and
 where instructional responses to those variations are not constrained by the
 researcher but rather studied within a framework that encourages adapta-
 tion, which leads to the next characteristic.

4. *Adaptive and iterative.* In design research, a researcher begins
 with an assumption that an instructional intervention implemented at the
 beginning of a study may be quite different from the one that emerges at
 the end of the investigation. That is, as the initial intervention is imple-
 mented within continuous cycles of data collection and analysis that aim
 to determine what contextual factors enhance or inhibit the intervention's
 effectiveness, the new data obtained are then used to modify the interven-
 tion and how it is implemented, as needed. Whether these cycles of imple-
 mentation and revision are well defined or fluid, a researcher must provide
 evidence of rigorous data collection and analysis to guide modifications
 within this iterative process and to determine whether desired effects were
 achieved. Because a researcher engages in an ongoing determination of

progress toward a pedagogical goal, establishing a baseline of conditions and/or performance may be necessary. That design research is iterative and involves fine-tuning instructional interventions across many cycles of data collection and responses to those data also suggests that studies should be conducted across a reasonable amount of time, usually months.

5. *Transformational*. Although this characteristic may not always be explicitly acknowledged in a particular study, there is often an assumption that the intervention may transform teaching and learning or the educational environment in some way. That assumption is based on the fact that the intervention was most likely selected for its strong potential to further a worthy educational goal that has been difficult to attain. Thus, design researchers are often guided by the realization that the intervention and its implementation may produce important unintended consequences. Looking for unintended consequences is also an incubator for building theory and for generating ideas for further research.

6. *Methodologically inclusive and flexible*. Conceptualizing and conducting design research is not driven mainly by a particular method or approach to collecting and analyzing data. Any approach to data collection and analysis may be appropriate to design research if it informs the implementation of an intervention, enables a researcher to determine where participants are in relation to the pedagogical goal being sought, and/or provides understandings of key factors and processes that inform practice and the testing, refinement, or development of pedagogical theory. Consequently, too, approaches to data collection and analysis may be adapted formatively in response to developments during an investigation or to a realization that more useful data or approaches might be better suited to circumstances that only become clear during data collection. The data may be quantitative (e.g., establishing a baseline of performance, attitudes, and motivation using standardized instruments that is compared pre- and postexperiment). However, because formative experiments clearly fall into what Salomon (1991) has termed *systemic*, as opposed to *analytic*, research, collecting and analyzing qualitative data are essential to conducting a formative experiment. Published formative experiments in literacy typically have involved mixed methods with all the attendant concerns, advantages, and standards of rigor associated with that research methodology (see Chatterji, 2004; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 1998).

7. *Pragmatic*. This characteristic, which we associate at least tacitly with design research, refers more broadly to the tenets of pragmatism as a philosophical position than to simply a focus on what works. For example, pragmatism values intuitive knowledge and promotes democratic ideals, including the involvement of practitioners and students in setting research agendas and modifying interventions. They invite more authentic collab-

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orative relationships between researchers and teachers. Pragmatism also
does not engage in arguing the ultimately unanswerable epistemological
questions about knowledge and knowledge generation that often distracts
researchers using other approaches (see Dillon et al., 2000). A pragmatic
view also focuses more on processes than on establishing clear causal rela-
tionships.

Standards of Rigor

For design research, standards of rigor exist in two dimensions. First, there
are the standards of rigor normally associated with conventional approaches
to collecting and analyzing qualitative or mixed methods data as they are
employed in a particular study. For example, using multiple sources of data,
triangulation of findings, member checks, and other means of building the
trustworthiness of conclusions seems particularly important for design
research. The second dimension includes standards of rigor associated spec-
ifically with design research. Although there is not widespread agreement
on such standards, we believe that there are several likely candidates, which
we have discussed in detail (see Reinking & Bradley, 2008). For example,
we believe that studies should exhibit conceptual rigor, which is primarily
conceptualizing, conducting, and reporting research that is consistent with
the defining characteristics outlined in the previous section. Studies that
have all or most of these defining characteristics are more conceptually
rigorous and true to the essence of this approach.

Rigorous studies also provide sufficient time to explore the effects of
the intervention and any modifications made to it. Months of concentrated
data collection are often demanded. In our own work using formative
experiments, we plan projects that go through several phases throughout
a school year starting with 4–6 weeks of gathering ethnographic data to
characterize the environment, several more weeks to gather baseline data,
at least 10–16 weeks of implementing and revising the intervention being
studied, and then baseline assessments and postintervention interviews.
Rigorous studies should also embrace interdisciplinary perspectives and
multiple theories, which is ideally accomplished through interdisciplinary
teams of researchers, although that ideal is often not feasible. Rigor can also
be enhanced by purposeful and careful selection of an appropriate research
site and explaining how and why it was selected. Usually, sites where the
odds of either failure or success are almost guaranteed are not the best
starting points for initial investigations. It is also particularly important
that a report of a study using this approach not suggest that the researcher
is an advocate for the intervention or is romanticizing its potential and
effects.

Because design research is pragmatic and guided by the metaphors of
engineering and ecology, researchers need to be skeptical, open to rejecting

preferred aspects of the intervention or preferred theories when they are not working well, comfortable with highlighting failures and problems, and cautious about overselling the merits of an intervention as a pedagogical panacea.

AN EXEMPLAR OF A FORMATIVE EXPERIMENT

As we indicated early in the chapter, several formative experiments in the area of literacy research have been published since we wrote an earlier version of this chapter. Thus, we have selected a more recent study conducted by Ivey and Broaddus (2007) as an exemplar for this updated version. As in the original chapter, we choose their study because (1) it focuses on literacy, (2) it was rigorously peer reviewed and published in a highly regarded journal, (3) it involved extensive data collection and analysis for an entire school year, and (4) it illustrates many of the characteristics of design research discussed previously in this chapter. To contextualize their study, Ivey and Broaddus investigated how to engage seventh- and eighth-grade native Spanish speakers in reading and writing during a language arts class. They also employed a set of questions that characterize the framework first proposed by Reinking and Watkins (2000), which has also been used by other literacy researchers (Bradley & Reinking, in press; Fisher, Frey, & Lapp, 2009; Lenski, 2001). Thus, each of the questions that follow represents a framework that has been used in several literacy studies. However, it is important to note that it is only one of several frameworks and approaches that might be employed within design research. It is also important to note that we have not included the authors' citations supporting the work reported in their article. We encourage interested readers to read the original article for such detail.

What Is the Pedagogical Goal and What Theory Establishes Its Value?

The pedagogical goal of the Ivey and Broaddus (2007) study was to facilitate the engagement of reading and writing among seventh- and eighth-grade native Spanish-speaking students who had recently immigrated to the United States and who were just beginning to read, write, and speak English. That goal was justified on the basis of theoretical and empirical research demonstrating the importance of engagement to learning, as opposed to compliance, and that time spent engaged in literacy activities is critical for reading achievement and vocabulary development. For example, they reported research suggesting that when students participate in classroom reading activities, they are more likely to read outside of school. Furthermore, when students are engaged in reading and writing outside of school, they are more

on or preferred theories when they are not highlighting failures and problems, and merits of an intervention as a pedagogical

EXPERIMENT

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d Broaddus (2007) study was to facili- writing among seventh- and eight-grade o had recently immigrated to the United to read, write, and speak English. That oretical and empirical research demon- ent to learning, as opposed to compli- n literacy activities is critical for read- velopment. For example, they reported ents participate in classroom reading d outside of school. Furthermore, when writing outside of school, they are more

likely to develop reading and writing competencies. Thus, engaging second-language learners who are just learning English in reading and writing activities in school is important for initiating learning inside and outside of school and for developing reading and writing competency.

What Classroom Intervention Has Potential to Achieve the Pedagogical Goal?

In conceptualizing the instructional intervention for their study, Ivey and Broaddus (2007) were informed by the existing literature comparing (1) first- and second-language literacy acquisition and (2) second-language literacy and adolescent literacy. Considering the points of disconnection and intersection across the literature, the researchers and teacher determined that the intervention should consist of two basic parts: self-selected readings and teacher-directed reading-writing activities. The decision to prioritize reading and writing above other literacy-related activities was based on evidence that engaged reading is associated with reading achievement and that it was the best context to meet the individual needs of students. To facilitate students' engagement during these activities, the researchers and teacher recognized the importance of providing a wide range of materials that varied in reading level, genre, and topic as well as culturally relevant materials. Furthermore, during self-selected reading, rather than model good reading habits, the teacher and researchers both coached and read to individual students. In addition, because these students were still developing reading skills and needed support, the adults focused on providing instructional support that encouraged student engagement, such as repeated reading, shared reading, and paired reading, rather than instruction that might interrupt student reading. Finally, teacher-directed reading-writing activities were initially conducted in whole-class or small-group settings and primarily focused on concepts likely to inspire students, such as topics that they may find personally or cultural relevant or topics considered to be appealing to young adolescents.

What Factors Enhance or Inhibit the Effectiveness of the Intervention in Achieving the Pedagogical Goal?

Guided by principles underlying mixed methods research, researchers conducting formative experiments often collect and analyze both qualitative and quantitative data for the purpose of determining progress toward a pedagogical goal and determining what factors enhance or inhibit progress. Toward that end, Ivey and Broaddus (2007) primarily collected and analyzed qualitative data. Specifically, data included classroom observations, student interviews, teacher-researcher debriefings, artifacts of students' reading and writing activities, reading logs, and researchers' notes and reflec-

tions, as well as frequency counts to document changes in the instructional environment. Using constant-comparative analysis, the researchers identified emerging hypotheses about factors that enhanced or inhibited progress toward the pedagogical goals, and they used that information to determine which practices needed to be discontinued, adapted, or transformed.

How Can the Intervention Be Modified to Achieve the Pedagogical Goal More Effectively?

A distinguishing characteristic of a formative experiment is that the intervention is modified, as needed, during the experiment toward more effectively or efficiently attaining the pedagogical goal that drives the investigation. Thus, on the basis of data collection and analysis, Ivey and Broaddus (2007) identified three categories of modification to improve the intervention aimed at increasing student engagement in reading and writing. First, despite providing a variety of materials for the students, the research team quickly realized that the materials were not meeting the individual needs of students during self-selected or teacher-directed activities. That is, to increase engagement, they needed a more deliberate approach to match students to text, and they needed to consider more carefully which materials were more effective for specific purposes. Over time they identified more appropriate materials that engaged students who were learning how to read, write, and speak English. Second, despite initially providing instructional supports, the researchers discovered that students needed additional teacher support to create meaning when using the texts. That is, choral and echo reading, which are helpful with younger literacy learners, were ineffective for many of the older second-language learners. Thus, two additional instructional practices to support students' ability to make meaning were added: (1) teacher read-aloud and book talk prior to students' self-selecting text and (2) teacher support to identify and explain unfamiliar concepts while students read. The last category of modification involved the scaffolding of writing experiences. That modification became necessary because the initial intervention that included the use of culturally relevant materials to inspire writing was, for many reasons, ineffective. Consequently, the teachers and researchers implemented the language experience approach, which had been shown to have potential for students of diverse background. Furthermore, because students were struggling with syntax and vocabulary, the teacher and researchers found that students became more engaged when they were provided a model for writing, particularly books that included familiar language or repetitive phrases. In sum, when data collection and analysis revealed that the initial instructional intervention, ground in theory and research, was "put to work," many of the intervention practices did not meet the individual needs of students, and it was necessary to draw on other theory and research to redesign the intervention.

to document changes in the instructional narrative analysis, the researchers identified factors that enhanced or inhibited progress they used that information to determine continued, adapted, or transformed.

Modified to Achieve Effectively?

A formative experiment is that the interesting the experiment toward more effective pedagogical goal that drives the investigation and analysis, Ivey and Broaddus modification to improve the intervention engagement in reading and writing. First, materials for the students, the research team were not meeting the individual needs teacher-directed activities. That is, to a more deliberate approach to match to consider more carefully which materials for purposes. Over time they identified engaged students who were learning English. Second, despite initially provided researchers discovered that students needed meaning when using the texts. That are helpful with younger literacy learners older second-language learners. Thus, to support students' ability to make read-aloud and book talk prior to student teacher support to identify and explain read. The last category of modification experiences. That modification became intervention that included the use of cultural writing was, for many reasons, ineffective researchers implemented the language shown to have potential for students are, because students were struggling teacher and researchers found that students they were provided a model for writing, familiar language or repetitive phrases. Analysis revealed that the initial instructional and research, was "put to work," did not meet the individual needs of draw on other theory and research to

What Unanticipated Positive or Negative Effects Does the Intervention Produce?

This question is consistent with the rationale for a formative experiment because it acknowledges that instructional interventions are never implemented in a vacuum and that complex interacting variables with multiple effects operate in any instructional context. Thus, upon reviewing the data, one unanticipated effect was the predominant role the researchers played in the intervention compared with the teacher and her assistants. This unanticipated effect occurred, in part, as the intervention evolved from a whole-class and small-group intervention to individual and paired work and as the adults become more proactive in regard to instruction students. That situation was compounded by the fact that the researchers gravitated toward the students who were the least engaged in reading and writing, and, thus, it become more imperative to modify the instructional intervention to meet their needs.

This situation highlights a potential challenge in conducting a formative experiment. That is, because this approach is a collaboration between researchers and teachers, the traditional roles assumed by researchers and teachers are often blurred. In this case, this shift led to the researchers assuming a stronger role in the implementation the intervention. Although this does not undermine issues illuminated by this study or the practices the researchers identified as effectively engaging second-language learners in reading and writing, it does underscore a defining characteristic of a formative experiment, which is to understand how an instructional intervention can be implemented effectively in an authentic instructional environment. As Ivey and Broaddus (2007) noted, they played a more prominent role in identifying and implementing modifications to the intervention. Thus, as they suggest, researchers may need to actively plan for opportunities to collaborate with teachers, and when researchers are involved with the implementation of intervention, they need to plan for gradual release of responsibility from the researchers to the teacher.

Has the Instructional Environment Changed as a Result of the Intervention?

This question is closely related to the previous one and is founded on the assumption that interventions most worthy of investigation are not only those that have potential to accomplish a pedagogical goal but often also those that have strong potential to transform positively the teaching and learning environment. Thus, the pedagogical goal of the Ivey and Broaddus (2007) study was to increase students' engagement in reading and writing; therefore, it would seem to have the potential to transform the class into a community of literacy learners. Yet data collection and analysis revealed little engagement in a whole-class or small-group teaching format because

engagement differed from student to student. Thus, to meet the needs of the class and the pedagogical goal of the study, the instructional environment shifted from whole-class and small-group work to individual and paired work. Furthermore, rather than the intervention activities per se leading the change, the adults needed to be more proactive and deliberate in identifying effective materials and practices and providing intensive individual instruction. Thus, data collection and analysis revealed that the instructional environment was transformed from class-oriented instruction to instruction matched to the individual needs of students.

CHALLENGES, LIMITATIONS, AND FUTURE DIRECTIONS

Because the literature on design research and the number of published studies that have used this approach have more than doubled since we wrote the original version of this chapter, it is now clearer where it stands within the larger landscape of education research. It is also clearer what challenges and limitations must be addressed and what the future may hold. The steadily increasing attention to design research within the research community, reinforced by the generally positive reactions we typically receive when we introduce this approach to our colleagues, to students, and to teachers, suggests that it still holds the conceptual power and intuitive appeal that captured the hearts and imaginations of its earliest pioneers such as Ann Brown. Nonetheless, it is also still the case that researchers and students using this approach may encounter misunderstandings, if not resistance, from reviewers of their work, although we suspect less so than when we wrote the original chapter. We believe its legitimacy has been adequately sealed within the mainstream of education research.

The increased attention has also attracted serious critiques that have identified conceptual, methodological, and practical issues and limitations that must be acknowledged and addressed. Most prominently, design research continues to project an amorphous methodological identity, as reflected in its unsettled terminology. Furthermore, although we have begun to see some boundary crossing, different disciplines within education and researchers from different methodological orientations still tend to conceive and implement this approach in sometimes fundamentally different ways and with different conceptual emphases. That may not necessarily be a limitation, especially if there is a common core of defining characteristics and generally accepted standards for rigor, such as those we have outlined in previous sections of this chapter. In fact, methodological openness and flexibility are two of those defining characteristics.

Nonetheless, this ambiguity and separation are often not well received by those who are more accustomed to tighter conceptual and methodological definitions and standards. For example, Dede (2004), in his thoughtful critique of design research, characterized it as "a kind of 'Swiss Army

to student. Thus, to meet the needs of the study, the instructional environment and small-group work to individual and than the intervention activities per se ded to be more proactive and deliber- s and practices and providing intensive collection and analysis revealed that the sformed from class-oriented instruction dual needs of students.

FUTURE DIRECTIONS

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Knife' of research . . . [entailing methods that] do a little of everything, but do nothing particularly well" (p. 106). Design research has also been criticized for being underconceptualized theoretically because of its focus on workability (see diSessa & Cobb, 2004) and overmethodologized, producing copious and unwieldy data (e.g., Dede, 2004). Likewise, Kelly (2004) argued that design research must be "undergirded by a conceptual structure that forms the basis for the warrants for [its] claims," or it will "contribute only haphazardly to an aggressive science of learning" (p. 118).

Design research certainly does run against the grain of firmly entrenched concepts in education research, such as establishing causal relations or expecting valid findings to generalize from a sample to a larger population. But rethinking or expanding these ideas is perhaps one of the important contributions of this approach because it reveals the limitations of investing too heavily in those concepts if we are to acknowledge the inherent messiness of classrooms, teaching, and learning and if we are to close the gap between research and practice. For example, design research, we believe, has reintroduced the need for broader views of generalization such as those proposed by Firestone (1993). In his view, generalization is more than extending the findings of a sample to a population; it also includes theoretical generalization (e.g., can theory generalize to practice?) and case-to-case generalization (e.g., a specific case generalizes more validly to another case in a similar context than it does to all cases in general). These concepts of generalization are particularly compatible with design research and may help education research break away from the constraints and limitations associated with trying to be strictly a social science (see Lagemann, 2000).

In our own involvement with conducting formative experiments, we have faced troubling methodological issues and practical challenges. For example, when we work closely with teachers in classrooms, we often become a factor influencing the direction and success of the intervention, which muddies our findings (see also the exemplar in the previous section). However, it also forces us to consider longer term relationships with teachers and to create research agendas that include multiple iterations over years and that involve a fading of our direct involvement, perhaps followed by a formative experiment that investigates a teacher development model aimed at helping teachers to invest in and implement the intervention. We have also struggled with deferring to teachers' judgment, beliefs, routines, and so forth when their perspectives and practices differ from our own deeply held beliefs about pedagogy. These, however, are important struggles that inform and enrich our research and keep us grounded in the realities of day-to-day practice in education and respectful of teachers' professional prerogatives. Such useful struggles are also a positive contribution of design research.

We do not believe that these challenges and limitations exceed those associated with other methodological approaches, and we believe that

some of them may be resolved as researchers gain more experience with design research and reach more consensus about its conceptual and methodological base and about standards of rigor. We are especially encouraged about the future because of funding agencies' increased acknowledgment of design research as a legitimate and desirable approach to research. Thus, we remain confidently optimistic about the future of design research and look forward to the directions this approach will take in the future and the extent to which it will be adopted by a new generation of researchers. We hope to have much more to report should this book eventually go into a third edition.

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