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## CHAPTER 8

# Connecting Research and Practice Using Formative and Design Experiments

David Reinking  
Barbara A. Bradley

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

—COLLINS (1999, p. 289)

**H**ow can and how should literacy research inform instructional practice? These questions are central to the rationale for formative, or design, experiments, the research methodology we present in this chapter. Educational researchers who have gravitated toward this methodology have typically done so 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 relation between conventional research methodologies and instructional practice. Thus, that is where we begin.

For example, at the time we are writing this chapter, the U.S. government is vigorously promoting the view that experimental methods should be the gold standard for implementing scientifically based reading instruction (National Reading Panel Report, 2000). Those who hold this view believe that practitioners should design and implement literacy instruction to be consistent with generalizations derived across 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.

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.

For some researchers, the best of all worlds would be 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 not often been the case. Not only have literacy researchers employing these different methodologies been unlikely to collaborate in gathering data or synthesizing their respective findings (see Oldfather & Wigfield, 1996, for a notable exception), they typically work in distinctly separate research communities sometimes characterized by competition, if not animosity. Further, as many writers have noted, educational research in general, whether it be experimental or naturalistic, has not had a pervasive influence on classroom practice (e.g., Collins, 1999; Eisenhart & Borko, 1993; Lagemann, 2000). One commentator has characterized educational research as a "lesser form of knowledge" and consequently suggests that the field should lower its expectations about the extent to which research should guide instructional practice (Labaree, 1998, p. 4).

The explanation for the gap between research and practice is surely a complicated one. However, we agree with those who have

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by naturalistic methodologies, on the useful information, but of a different kind. are suited to a deep examination of par- s, they produce data that are perhaps tioners understand the complexities and practice. When studying classroom in- ten aim to reveal aspects of instruction- se go unnoticed by practitioners or that erstand and reflect on their practice. t practice or conclusions about best goal of such studies, although they may in light of pedagogical theories, educa- gies designed to provide a broad frame investigated typically are not related to evement but, instead, tend to focus on -developing motivation to read, acquir- n texts, and promoting sociocultural

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pointed out that a major reason this gap exists is that the work of educational researchers and the work of teachers are often disconnected. For example, Eisenhart and Borko (1993) have stated, "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 practice" (p. 79).

What is missing, we argue, is a research methodology that addresses specifically how promising instructional interventions might be implemented in classrooms to achieve valued pedagogical goals. Such a methodology would acknowledge the complexities of classroom teaching and be aligned with the day-to-day management of that complexity. It not only would enlighten practitioners about research-based pedagogies to enhance literacy, but would provide them with specific insights about how they might effectively implement instructional interventions. In short, it would narrow the gap between research and practice, serving as an intermediary between the findings generated by other methodologies and the realities of teaching. Formative, or design, experiments aim to fill that gap, and they may 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 explain this methodology in relation to other methodologies, trace its roots, offer general guidelines for those who wish to employ it, and provide one example of 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)

#### A Note about Terminology

Before addressing the question central to this section, we want to simplify the terminology we use in the remainder of this chapter. If there are differences between formative experiments and design experiments, those differences are subtle and have not been clearly delineated in the literature. Design experiments perhaps focus on

broader educational goals and theory development (Design-Based Research Collective, 2003) and less specifically on a particular intervention, whereas the emphasis may be somewhat reversed for those who prefer the term *formative experiments*. Nonetheless, we believe that formative and design experiments are more closely related to each other than they are to other approaches that have similar goals and use similar approaches to data collection such as formative evaluation (Flagg, 1990), situated evaluation (Bruce & Rubin, 1993), rapid prototyping (Tripp & Bichelmeyer, 1990), and developmental work research (Engstrom, Miettinen, & Punamäki, 1998). Thus, for the sake of economy, we use both terms interchangeably but in most cases use *formative experiment*. We choose the term *formative experiment* over *design experiment* for no other reason than we have adopted that term in our own work and it has been used by other literacy researchers (e.g., Jimenez, 1997; Neuman, 1999). However, we wish to emphasize that one of the earliest references to the methodology underlying both terms was referred to as a "design experiment" (Brown, 1992, p. 141) and that term continues to be used by some researchers (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Both terms, *formative* and *design*, as we will explain in subsequent sections of this chapter, highlight important dimensions of this methodology.

### Conceptualizing Formative Experiments in Relation to Other Methodologies

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.

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

Formative experiments 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 by other research methodologies. That is, scientific inquiry comparing the effectiveness of alternative instructional interventions provide useful generalizations across diverse contexts. However, experimental studies of classroom interventions must simplify and control the wide range of variation that is inherent in classrooms and schools and that often influences the effectiveness of an inter-

and theory development (Design-Based and less specifically on a particular intervention) may be somewhat reversed for those *formative experiments*. Nonetheless, we believe *formative experiments* are more closely related to other approaches that have similar goals to data collection such as formative evaluation (Bruce & Rubin, 1993), Bichelmeyer, 1990), and developmental (Lietinen, & Punamäki, 1998). Thus, for both terms interchangeably but in most We choose the term *formative experiment* other reason than we have adopted that has been used by other literacy research (Luman, 1999). However, we wish to emphasize references to the methodology understood to as a "design experiment" (Brown, continues to be used by some researchers (Lehrer, & Schauble, 2003). Both terms, we will explain in subsequent sections of this paper the dimensions of this methodology.

## Experiments Methodologies

Instructional interventions work can be derived from the task of engineering them

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

often sits in the uneasy intersection of design and engineering.

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A neglected gap in research aimed at design experiments they address more directly the questions designers face and that are not addressed by traditional methodologies. That is, scientific inquiry comparative instructional interventions promote across diverse contexts. However, experimental interventions must simplify and accommodate variation that is inherent in classrooms and how it influences the effectiveness of an inter-

vention in a particular classroom (Labbo & Reinking, 1999). Further, 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). Ignoring the panoply of variables that are continually fluctuating in classrooms and failing to adapt instruction to those variables are contrary to the essence of 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, unlike experimental or naturalistic studies of instructional interventions, accommodate both the variation inherent in classrooms and the need to adapt interventions in response to relevant variation.

To oversimplify 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?) A formative experiment, on the other hand, is best suited for the following type of question: "Given that intervention X (or pedagogical theory Y) shows promise to bring about a valued pedagogical goal, can it be implemented to accomplish that goal, and, if so, how?" (What could be?) Two other key questions are important to understanding a formative experiment: 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 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. (Or, in terms of the *design* in design experiments, how can instruction be designed to realize a pedagogical goal?)

A formative experiment is also an experiment, but in a sense broader than the formal hypothesis testing that guides a controlled 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 to note any unintended consequences; and (3) *hypothesis testing*, which is formal

experimentation to see whether alternative hypotheses are affirmed or negated. Formative experiments employ all three types of experimentation, just as reflective teachers do, but formative experiments entail a more systematic record of this experimentation and typically include collegial discussions and overt reflections based on careful data collection. Thus, formative experiments, because they address questions clearly relevant to practitioners, and because they employ forms of experimentation similar to practitioners, are more directly related to practice than to other forms of research and are more likely to appeal to practitioners. A further advantage of formative experiments, when compared to more dominant 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.

Engineering might be a useful analogy for conceptualizing formative experiments 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 practical value. 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 sometime relevant variables only emerge in the real-world application of theoretical or laboratory research. Wind tunnels are clearly useful in designing airplanes consistent with the principles of aerodynamics, but wind tunnels may not easily simulate the sustained wear some parts experience during thousands of hours of real flying conditions. Further, the work of engineers in the real world of 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 practical goals. He highlights Louis Pasteur's work in seeking ways to preserve food as a classic example of how the distinction between basic and applied research is often 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

Other alternative hypotheses are affirmed. Experiments employ all three types of experiments that teachers do, but formative experiments stand out as a part of this experimentation and typically involve reflective and overt reflections based on careful analysis of formative experiments, because they address the needs of practitioners, and because they employ methods similar to practitioners, are more directly comparable to other forms of research and are more likely to be accepted. A further advantage of formative experiments over more dominant research methodologies, is that they acknowledge the importance of intuitive practitioners and propagating that knowledge within a system-oriented research.

A useful analogy for conceptualizing formative experiments is the design experiment. Design experiments are more apt. Engineering experiments are a mix of theoretical and empirical research to design products. Their work builds bridges (sometimes between theory and research, and practical application). But, the real world is the essence of their work, where their solutions only emerge in the real-world application of their research. Wind tunnels are clearly useful as a part of research. Wind tunnels are clearly useful as a part of research consistent with the principles of aerodynamics, but they do not easily simulate the sustained wear some aircraft experience over thousands of hours of real flying conditions. Design experiments in the real world of practical application often stimulate the need for more theoretical research. In fact, Stokes (1997) has argued that practical research and theoretical concepts in science emerge through attention on achieving practical goals. He has argued that work in seeking ways to preserve food as a part of research is a distinction between basic and applied research and a state dichotomy.

Design experiments, what has or has not worked under a variety of conditions allows engineers and mechanics to acquire practical knowledge that may lead them occasionally to work on theoretical theory and research. Duffy (1994) has argued that intuitive knowledge is necessary for teaching and research findings as something to be handed over to practitioners. Design research ignores the reality that teachers must know not only when to apply findings, how to adapt them to their needs, and even when it might be appropriate to

ignore the findings altogether" (p. 19). Thus, formative experiments 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 formative experiments focus 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).

A formative experiment then, with its emphasis on workability or achievability, is a methodological parallel to a science of engineering that tests theory and empirical research in the real world of practice. It employs systematic and rigorous data collection, qualitative and quantitative, toward achieving a desired pedagogical goal while valuing intuitive knowledge and engaging in experimentation beyond formal hypotheses testing. Further, formative experiments are aimed toward generating research that not only is more directly relevant to practice but can inform theory development and identify variables that might be investigated through conventional experimental or naturalistic approaches. Nonetheless, despite our use of engineering as a metaphor to understand formative experiments, like most metaphors, it has its limits. We do not wish to suggest that formative experiments should be associated with the concept of social engineering, which suggests that human interactions can be or ought to be controlled or manipulated to accomplish a researcher's vision of the world. The pedagogical goals that drive formative experiments do not exist in a vacuum, but exist, like all educational research, within a web of sometime conflicting values, ideologies, and epistemologies.

## HISTORICAL AND PARADIGMATIC 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 formative experiments as a research methodology is akin to identifying the headwaters of a river. There seems to be no single, clearly identifiable source for the concept or for the term.

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. Many of these writers also saw improving education as the critical goal of educational research (see Moll & Diaz, 1987). However, formative experiments, or related methodologies, have not emerged strictly among researchers interested in conventional school learning. They have been employed by researchers in other fields interested in implementing effective interventions in a variety of areas (e.g., health care—see Gittleson et al., 1998, for an example and a review; communication design—see Atkin & Freimuth, 1991; and work environments—see Engeström et al., 1998).

Jacob (1992), who discussed formative experiments in her chapter in the *The Handbook of Qualitative Research in Education*, traced the roots of formative experiments to neo-Vygotskian scholars (e.g., Davydov, 1988) and to cognitive psychologists who became interested in the social construction of psychological tasks. Newman, Griffin, and Cole (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. That study was important because it was the first to outline and illustrate a specific methodological framework for conducting a formative experiment. Brown (1992) contributed an often-cited article that described her own turn as a classical theorist 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). Her article was particularly important in familiarizing literacy researchers with this methodology because of her well-known and highly regarded work on the metacognitive aspects of reading.

Since the mid-1990s, several literacy researchers have published work employing the methodology of formative experiments. Several of these studies (Jiménez, 1997; Neuman, 1999; Reinking & Watkins, 2000), have been published in *Reading Research Quarterly*, a highly regarded outlet for literacy research. Contemporary with our own research using this methodology, we have attempted to articulate the basis and need for formative experiments, and more important how methodology might be translated into specific methods for conducting a formative experiment (Baumann, Dillon, Shockley, Alvermann, & Reinking, 1996; Reinking & Pickle, 1993; Reinking &



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Watkins, 2000). However, it is clear to us, particularly after partici-  
pating in a symposium on formative experiments at the annual meet-  
ing of National Reading Conference in 1997, that literacy researchers  
employing formative experiments, while they may share many funda-  
mental assumptions about methodology, do not have a consensus  
about its procedural and interpretive dimensions (see Neuman,  
Jimenez, Reinking, & Au, 1997).

As we have noted previously in this chapter, formative experi-  
ments share many conceptual and methodological characteristics  
with related approaches referred to by different terms. Perhaps most  
closely related to formative experiments is Bruce and Rubin's (1993)  
work, which they describe as *situated evaluation*. The need for situated  
evaluation emerged from their discovery that teachers did not neces-  
sarily implement innovative instructional interventions, in this case a  
computer-based intervention to enhance purposeful reading and  
writing, in ways consistent with the intent of the developers. We be-  
lieve that such an insight is a critical but neglected one in other edu-  
cational research methodologies and a key advantage of formative ex-  
periments. Their work also points to another aspect of formative  
experiments. They have been used frequently to investigate instruc-  
tional innovations, particularly the use of new computer-based tech-  
nologies. The belief that new technologies have the potential to  
transform instruction has led several researchers who share this belief  
to employ formative experiments in their research. It also explains  
why those in the field of instructional technology have developed  
and used related concepts such as formative evaluation (Flagg, 1990)  
and rapid prototyping (Tripp & Bichelmeyer, 1990). This plethora of  
terms and interpretations gives testimony to the conceptual power of  
formative experiments but at the same time illustrates the muddiness  
of the waters concerning precisely what they are conceptually and  
procedurally.

To our knowledge, no one has proposed an explicit theoretical,  
paradigmatic, or philosophical foundation for formative experiments  
as a research methodology. However, we believe that such a founda-  
tion operates implicitly among those who have used formative experi-  
ments and might be articulated more explicitly within the existing  
literature. For example, activity theory (Engeström et al., 1998) has  
explicitly guided developmental work research, a methodology simi-  
lar to formative experiments. Activity theory suggests that change in  
work environments can only be brought about by acknowledging the  
relation between sociohistorical context, the objects and tools that  
are integral to the work environment, and the social interactions that  
mediate their use. However, we believe that formative experiments

and related methodologies fit most naturally with the philosophical tenets of pragmatism, which has been associated with education and education research since John Dewey and which has been revived as a paradigm useful to educational research in general (Cherryholmes, 1993) and to literacy research in particular (Dillon, O'Brien, & Heilman, 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, which is illustrated in the example that follows subsequently in this chapter.

### 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)

Given the diverse origins of formative experiments and related methodologies, and the lack of a well-articulated paradigmatic frame, it is understandable that there is no consensual, authoritative source explicitly identifying their essential characteristics or procedural components. That is, there is no equivalent to Campbell and Stanley (1963) in designing and conducting experimental studies or, for example, to Strauss and Corbin (1990) for naturalistic studies. In fact, given the emphasis on educational outcomes in formative experiments, such specificity may actually work against the flexibility and fluidity that are necessary for researchers who employ this methodology and that have been argued to be necessary to moving the field of literacy research forward (Dillon et al., 2000). This lack of specificity might even be considered one of a formative experiment's distinguishing characteristics. However, it adds a burden to researchers who wish to conduct a formative experiment. As Eisenhart and Borko (1993) stated subsequent to the quote introducing this section, "[using alternative methodologies of classroom research] demands more thought and explanation than might be necessary if conventional procedures were used" (p. 11).

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## METHODOLOGICAL CHARACTERISTICS

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Nonetheless, several general characteristics establish the appropriateness, rigor, and validity of formative experiments and together distinguish them from other related methodologies. We offer the following characteristics adapting and extending the work of Cobb et al. (2003):

1. *Theoretical*. Theory plays a predominant role in a formative experiment, which distinguishes it from related data collection methodologies such as formative evaluation (Flagg, 1990) and rapid prototyping (Tripp & Bichelmeyer, 1990) that are often atheoretical in seeking ways to reach a particular goal. As is the case with other research methodologies, theory in a formative experiment is used to justify the importance of the inquiry, to provide a rationale for the intervention, interpret findings, contextualize conclusions, and so forth. However, as Cobb et al. (2003) state, 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 learning" [italics in the original]. Further, they state that in developing theories "design experiments 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*" (italics in original, p. 10). That is, theories that do not directly inform practice are at best tangential to a formative experiment.

2. *Interventionist and goal oriented*. Formative experiments investigate how to improve education and learning toward well-specified goals that are explicitly justified in relation to theory and practice. Thus, researchers conducting formative experiments must explicitly identify and justify a goal accompanied by a scholarly explanation of why it is worthy of investigation. Moreover, a researcher must specify a planned intervention believed to have promise in making progress toward that goal. The intervention, too, must be justified in terms of theory and practice. In most formative experiments the intervention is innovative; however, in our view, it need not be. That is, a formative experiment might examine an intervention that is well established in the literature and/or practice and that has perhaps been investigated using more conventional research methods.

3. *Iterative*. The initial intervention is implemented within a continuous cycle of data collection and analysis aimed at determining what contextual factors enhance or inhibit the intervention's effectiveness. These data are used to modify the intervention and how it is implemented, as needed. Cycles of implementation and revision may be fluid, but a researcher must provide evidence of rigorous data

collection and analysis to guide this iterative process. Because a researcher engages in an ongoing determination of progress toward a pedagogical goal, establishing a baseline of conditions and/or performance is a procedural necessity. That formative experiments are iterative and involve fine-tuning instructional interventions also requires that they be conducted across a reasonable amount of time, at least many weeks, if not months.

4. *Transformational*. There is an assumption that the intervention may transform the educational environment in some way. This 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. However, formative experiments are also guided by the realization that the intervention and its implementation within the context of a formative experiment may produce important unintended consequences. This aspect of formative experiments is important because it may contribute to building theory, and perhaps to suggesting ideas for further research.

5. *Methodologically inclusive and flexible*. Conceptualizing and conducting a formative experiment are not driven mainly by a particular method of collecting and analyzing data. Any approach to data collection and analysis may be appropriate to formative experiments if a researcher can justify how it furthers understanding about the effects of the intervention and how it might be implemented more effectively. Likewise, approaches to data collection and analysis may be adapted in response to developments during an investigation. Baseline data may be quantitative using standardized or experimenter-developed instruments, and statistical comparisons might be made between pre- and postexperiment performance. 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. Thus, formative experiments are likely to involve mixed methods with all the attendant concerns, advantages, and standards of rigor associated with that research methodology (see Tashakori & Teddlie, 1998).

6. *Pragmatic*. This characteristic refers more broadly to the tenets of pragmatism than to simply a focus on what works. For example, pragmatism encompasses the broader view of experimentation to which we alluded in a previous section of this chapter, a valuing of intuitive knowledge, and an investment in democratic ideals, including the involvement of practitioners and students in setting research agendas and modifying interventions (see Dillon et al., 2000). Thus, formative experiments are typically collaborative efforts that involve

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r further research.

*and flexible.* Conceptualizing and con-  
t are not driven mainly by a particular  
yzing data. Any approach to data col-  
ropriate to formative experiments if a  
rthers understanding about the effects  
t might be implemented more effec-  
data collection and analysis may be  
oments during an investigation. Base-  
using standardized or experimenter-  
atistical comparisons might be made  
ent performance. However, because  
fall into what Salomon (1991) has  
*analytic*, research, collecting and ana-  
tial to conducting a formative experi-  
ents are likely to involve mixed meth-  
ncerns, advantages, and standards of  
arch methodology (see Tashakori &

istic refers more broadly to the tenets  
a focus on what works. For example,  
broader view of experimentation to  
section of this chapter, a valuing of in-  
tment in democratic ideals, including  
ers and students in setting research  
tions (see Dillon et al., 2000). Thus,  
ally collaborative efforts that involve

not only a researcher or research team, but also practitioners. There  
is also precedent for teachers to conduct formative experiments in-  
volving their own practice, in which formative experiments overlap  
with models of action research (Duffy-Hester, 1999; Garfield, 2000).

### AN EXEMPLAR OF A FORMATIVE EXPERIMENT

Relatively few formative experiments have been conducted and few  
have been published in mainstream educational research journals. In  
selecting an illustrative example for this section, we chose our own  
work (Reinking & Watkins, 2000), 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 in three  
schools and eight classrooms during 2 years, and (4) it illustrates the  
characteristics of formative experiments as presented previously in  
this chapter. Of course, it is also a study about which we have first-  
hand knowledge. However, because formative experiments represent  
an evolving methodology that accommodates flexibility, we empha-  
size that our example is not meant to be definitive. For readers who  
wish to consider a range of possible options for using this methodol-  
ogy in relation to literacy research, we recommend the following:  
Baumann (2003), Duffy-Hester, (1999), Garfield (2000), Jimenez  
(1997), Neuman (1999), and Newman (1990).

Our study investigated how engaging teachers and students in  
creating multimedia book reviews as an alternative to conventional  
book reports could increase elementary students' independent read-  
ing. We addressed six questions that provided a framework for con-  
ceptualizing, designing, and reporting our study. These six questions,  
which follow here, parallel the distinguishing characteristics of for-  
mative experiments introduced previously in this chapter, and we be-  
lieve that these questions may be a useful guide for others interested  
in conducting formative experiments.

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

Our pedagogical goal was to increase the independent reading of ele-  
mentary school students. We justified that goal on the basis of theo-  
retical and empirical support for the importance of independent  
reading in enhancing literacy development among elementary school  
students. For example, on the theoretical side was the work of  
Stanovich (1986), who argued that discrepancies in reading perfor-

mance widens among young readers as poor students read less and good students read more (what he called "Matthew effects," after the biblical passage about the rich becoming richer and the poor becoming poorer). On the empirical side, we cited evidence that the amount of reading and positive attitudes toward reading decrease as students move through the elementary grades (e.g., see McKenna, Kear, & Ellsworth, 1995). Initially, our goal was twofold. That is, we aimed to increase both the amount and diversity of independent reading. However, for various reasons, during the study we abandoned the goal of diversity because it seemed less relevant to the teachers and students we worked with and less connected to the potential benefits of independent reading. This reformulating of goals illustrates the flexibility of formative experiments and how implementing theory in practice may lead to reshaping pedagogical theory.

### **What Classroom Intervention Has Potential to Achieve the Pedagogical Goal?**

In conceptualizing the study, we believed that an innovative use of computer technology might further the pedagogical goal. Specifically, we engaged teachers and students in creating a multimedia database about the books individual students were reading toward stimulating more interesting and creative responses to books and more interactions about independent reading among students. Our stance was supported by the often-cited limitations of widely used activities such as book reports and, more recently, computer-based activities such as the Accelerated Reader program based on extrinsic rewards and low-level, factual responses to texts (most recently supported by the work of Biggers, 2001). We believed that this innovative, technology-based intervention had potential to transform the dynamics of how teachers and students interacted about independent reading, although its implementation presented some formidable logistical obstacles, as is the case with many technology-based instructional activities. This emphasis on transforming instruction through innovative, often technology-based, interventions is consistent with how formative experiments have often been used.

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

Members of the research team collected various data to determine progress toward our pedagogical goal and what factors were enhancing or inhibiting progress. Data collection began by recording our ex-

ing readers as poor students read less and what he called "Matthew effects," after the rich becoming richer and the poor becoming poorer. On the empirical side, we cited evidence that the positive attitudes toward reading decrease as the elementary grades (e.g., see McKenna, 1996). Initially, our goal was twofold. That is, we wanted to increase the amount and diversity of independent reading for various reasons, during the study we abandoned it because it seemed less relevant to the goal of independent reading. This reformulating of goals and objectives of formative experiments and how implemented may lead to reshaping pedagogical theory.

### Intervention Has Potential to Achieve

In our study, we believed that an innovative use of technology could further the pedagogical goal. Specifically, we wanted students in creating a multimedia database to help all students were reading toward stimulating positive responses to books and more interactive reading among students. Our stance was based on the cited limitations of widely used activities such as, more recently, computer-based activities in a reader program based on extrinsic rewards and responses to texts (most recently supported by research). We believed that this innovative, technology-based had potential to transform the dynamics of how students interacted about independent reading. The intervention presented some formidable logistical challenges with many technology-based instructional activities. Transforming instruction through innovative interventions is consistent with how it has often been used.

### Inhibit the Effectiveness of Achieving the Pedagogical Goal?

The research team collected various data to determine the pedagogical goal and what factors were enhancing it. Data collection began by recording our ex-

periences in several meetings with teachers before the school year began to acquaint them with our proposed intervention, our rationale, their investment in and ideas about it, and so forth. Before implementing a first draft of the intervention early in the school year, we gathered detailed observational data to characterize the schools and classrooms in which we worked. We also collected data to establish a baseline of independent reading and attitudes about reading in and out of school. These data included observational and interview data, a standardized measure of reading attitudes, and a survey completed by students' teachers and parents. Thus, we gathered both qualitative and quantitative data guided by principles underlying mixed-methods research (see Tashakori & Teddlie, 1998). When the intervention was implemented, we gathered primarily qualitative data comprised mainly of classroom observations two to three times a week to determine what aspects of the intervention were working or not, and why. However, data also included interviews with teachers, parents, and students, as well as an analysis of instructional artifacts produced in conjunction with the intervention. We also scheduled regular meetings with the teachers, typically after school, to discuss our mutual observations and plan accordingly.

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

A distinguishing characteristic of formative experiments is that the instructional intervention of interest is modified as needed during the experiment toward more effectively or efficiently attaining the pedagogical goal that drives the investigation. Some modifications are in response to everyday variation in the instructional context, and are typical of the adaptations that practitioners must continuously address. For example, the number of computers available in the schools and whether they were placed in classrooms or a computer lab required modifications in the way the intervention was implemented. However, the systematic collection of data as described under the previous question also led to insights suggesting sometimes more subtle modifications. For example, in one classroom with a relatively high proportion of struggling readers, few students seemed interested in entering book reviews. Analyzing our observational data and interviews with students and teachers, we hypothesized that the struggling readers were reluctant to enter into the database the below-grade-level books they were reading, because it drew attention to their difficulties. That dynamic was easily changed after discussing our theories with the teacher who subsequently announced to the

class that she hoped some students would enter easier books because the database would be eventually used by students in lower grades.

### **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, as we gathered and analyzed data focused on the intervention, we also noted how engaging teachers and students in creating multimedia book reviews had effects not directly related to our specified pedagogical goal. For example, we noted that the intervention heightened concern for the mechanics of writing, because the database for book reviews was designed to be used publicly beyond the classroom; that teachers became more involved in professional development activities and that their involvement became more supported by central administration, more or less as a consequence of their involvement with a research project; that parents become more involved in classroom activities as they became needed helpers in the computer lab of one school, although this effect was not always positive; and that special education students seemed to take on a different persona in the computer lab than they did in other school contexts. Some of the more positive unintended effects relate to other valued pedagogical goals and may become the grist for further studies involving different goals and interventions.

### **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 also those that have strong potential to transform positively the teaching and learning environment. In our study, for example, we saw the intervention as having potential to transform teachers' and students' orientation to independent reading and particularly teachers' orientation to integrating technology into their instruction. Thus, our data collection and analysis attended to these and other possible transformations. We found evidence of such transformations in some of the classrooms. For example, several teachers abandoned activities that relied more on extrinsic motivation to promote independent



students would enter easier books because actually used by students in lower grades.

### ve or Negative Effects Does

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reading and they began to integrate some more creative and engaging  
 computer-based activities in other curricular areas. Such transforma-  
 tions did not occur in other classrooms, but our data revealed possi-  
 ble explanations. For example, in one school a top-down and heavy-  
 handed administrative environment seemed to stifle creativity and  
 experimentation among the teaching staff. Thus, in addressing this  
 question and the previous one, a formative experiment involves an  
 expansive examination of all aspects of an intervention's effects.

## THE NEED FOR FORMATIVE EXPERIMENTS

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 believe that Ebel's words are more poignant today than they were  
 more than 20 years ago when he issued this challenge as President of  
 the American Educational Research Association. His challenge, as  
 stated in these few words, perhaps best represents the imperative un-  
 derlying all the quotes presented in this chapter suggesting that re-  
 search play a unique and more active and direct role in improving  
 teaching and learning toward furthering valued pedagogical goals.  
 Further, during the intervening years, there has been little evidence  
 that educational research has provided strong guidance for practi-  
 tioners who wish to implement interventions that have theoretical  
 grounding and that have received empirical support through experi-  
 mental methods. Neither has the turn toward naturalistic methodol-  
 ogies, which has occurred since his remarks, produced specific guid-  
 ance about how practitioners might act on the important insights  
 such methodologies provide. Not only have established research  
 methodologies not addressed Ebel's challenge, it is clear today that  
 researchers are increasingly being held accountable to demonstrate  
 the fruits of their labors, often from the narrow perspective of quanti-  
 fiable, experimental data that are far removed from the realities of  
 classroom practice.

Thus, we believe formative experiments fill an important, indeed  
 vital and neglected, niche within the diverse methodologies that  
 might be employed within the educational research community. That  
 is not to argue that formative experiments are superior to more estab-  
 lished and more widely used methodologies or that they should re-

place them, only that those methodologies are decidedly incomplete without the insights formative experiments are aimed at providing. We believe that there must be a balance between understanding how education works or might work and conducting research aimed specifically at determining how it might work better through methods firmly grounded in the realities faced by practitioners. We believe that formative experiments provide a rigorous methodology that fills a gap between other research methodologies and instructional practice and that they do so by valuing both quantitative and qualitative data involving processes and toward ends that are readily accepted and understood by practitioners and the general public. We hope that this chapter serves to advance awareness of what we believe to be an exceptionally useful and timely methodology and that more researchers will consider employing this methodology to address important issues related to instructional practice.

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methodologies are decidedly incomplete. The experiments are aimed at providing a balance between understanding how to think and conducting research aimed specifically at what might work better through methods that are faced by practitioners. We believe we can provide a rigorous methodology that fills the gaps in current methodologies and instructional practices by combining both quantitative and qualitative methods toward ends that are readily accepted by practitioners and the general public. We hope to increase awareness of what we believe to be a more timely methodology and that more readily integrates this methodology to address instructional practice.

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