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SPECIAL ISSUE:
DESIGN-BASED RESEARCH: CLARIFYING THE TERMS

Sasha Barab
Guest Editor
Special Issues Editor

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**SPECIAL ISSUE:
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Design-Based Research: Putting a Stake in the Ground

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The emerging field of the *learning sciences* is one that is interdisciplinary, drawing on multiple theoretical perspectives and research paradigms so as to build understandings of the nature and conditions of learning, cognition, and development. Learning sciences researchers investigate cognition in context, at times emphasizing one more than the other but with the broad goal of developing evidence-based claims derived from both laboratory-based and naturalistic investigations that result in knowledge about how people learn. This work can involve the development of technological tools, curriculum, and especially theory that can be used to understand and support learning. A fundamental assumption of many learning scientists is that cognition is not a thing located within the individual thinker but is a process that is distributed across the knower, the environment in which knowing occurs, and the activity in which the learner participates. In other words, learning, cognition, knowing, and context are irreducibly co-constituted and cannot be treated as isolated entities or processes.

If one believes that *context matters* in terms of learning and cognition, research paradigms that simply examine these processes as isolated variables within laboratory or other impoverished contexts of participation will necessarily lead to an incomplete understanding of their relevance in more naturalistic settings (Brown, 1992).¹ Alternatively, simply observing learning and cognition as they naturally

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¹This special issue is dedicated to the memory and intellectual contributions of Ann Brown, who so clearly led the way in illuminating for the field the challenges and opportunities discussed in this issue.

occur in the world is not adequate given that learning scientists frequently have transformative agendas. Education is an applied field, and learning scientists bring agendas to their work, seeking to produce specific results such as engaging students in the making of science, creating online communities for professional development, or creating history classrooms that confront students preexisting beliefs about race, gender, or class. As such, learning scientists have found that they must develop technological tools, curriculum, and especially theories that help them systematically understand and predict how learning occurs. Such design research offers several benefits: research results that consider the role of social context and have better potential for influencing educational practice, tangible products, and programs that can be adopted elsewhere; and research results that are validated through the consequences of their use, providing consequential evidence or validity (Messick, 1992). However, participating in local educational practices places researchers in the role of curriculum designers, and implicitly, curriculum theorists who are directly positioned in social and political contexts of educational practice (both global and local) and who are accountable for the social and political consequences of their research programs.

Increasingly, learning scientists are finding themselves developing contexts, frameworks, tools and pedagogical models consistent with and to better understand emerging pedagogical theories or ontological commitments (see diSessa & Cobb, this issue). In these contexts, the research moves beyond simply observing and actually involves systematically engineering these contexts in ways that allow us to improve and generate evidence-based claims about learning. The commitment to examining learning in naturalistic contexts, many of which are designed and systematically changed by the researcher, necessitates the development of a methodological toolkit for deriving evidence-based claims from these contexts. One such methodology that has grown in application is that of design experimentation or design-based research, frequently traced back to the work of Ann Brown (1992) and Alan Collins (1992).

Design-based research is not so much *an* approach as it is a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings. Cobb, diSessa, Lehrer, & Schauble (2003) stated:

Prototypically, design experiments entail both “engineering” particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them. This designed context is subject to test and revision, and the successive iterations that result play a role similar to that of systematic variation in experiment. (p. 9)

They further suggested that design-based research has a number of common features, including the fact that they result in the production of theories on learning

and teaching, are interventionist (involving some sort of design), take place in naturalistic contexts, and are iterative. Design-based research is not simply a type of formative evaluation that allows learning scientists to better understand the ecological validity of theoretical claims generated in the laboratory. Design-based research, as conceived by Ann Brown (1992), was introduced with the expectation that researchers would systemically adjust various aspects of the designed context so that each adjustment served as a type of experimentation that allowed the researchers to test and generate theory in naturalistic contexts.

Although design-based research has the potential to offer a useful methodological toolkit to those researchers committed to understanding variables within naturalistic contexts, there are many unresolved questions that we as a community must address if our assertions are going to be deemed credible and trustworthy to others. Some questions are: What are the core foci of design-based research and what delineates it from other forms of research? What counts as reasonable and useful warrants for advancing assertions investigated through this type of research? What are the boundaries of a naturalistic context? How do we control researcher bias in selecting evidence, in reporting observations, and in developing trustworthy claims? How do we understand the contextuality of research claims generated *in situ* and use them to inform broader practice? In the following, we begin the process of responding to these questions, a process that is taken up in greater detail through the core articles and commentaries that comprise this special issue and that we hope will be taken up over the next decade by our colleagues.

CHARACTERIZING DESIGN-BASED RESEARCH

In understanding the need for new methods, it is important that one clarifies the distinction between existing methods for understanding learning and cognition and those central to design-based research. Collins, Joseph, and Bielaczyc (this issue) undertake this issue in their manuscript, contrasting several different methodologies with design-based research. They posit seven major differences between traditional psychological methods and the design-experiment methodology (see Table 1 for an abbreviated list). Central to this distinction is that design-based research focuses on understanding the messiness of real-world practice, with context being a core part of the story and not an extraneous variable to be trivialized. Further, design-based research involves flexible design revision, multiple dependent variables, and capturing social interaction. In addition, participants are not “subjects” assigned to treatments but instead are treated as co-participants in both the design and even the analysis. Last, given the focus on characterizing situations (as opposed to controlling variables), the focus of design-based research may be on

TABLE 1
Comparing Psychological Experimentation and Design-Based Research
Methods

<i>Category</i>	<i>Psychological Experimentation</i>	<i>Design-Based Research</i>
Location of research	Conducted in laboratory settings	Occurs in the buzzing, blooming confusion of real-life settings where most learning actually occurs
Complexity of variables	Frequently involves a single or a couple of dependent variables	Involves multiple dependent variables, including climate variables (e.g., collaboration among learners, available resources), outcome variables (e.g., learning of content, transfer), and system variables (e.g., dissemination, sustainability)
Focus of research	Focuses on identifying a few variables and holding them constant	Focuses on characterizing the situation in all its complexity, much of which is not now <i>a priori</i>
Unfolding of procedures	Uses fixed procedures	Involves flexible design revision in which there is a tentative initial set that are revised depending on their success in practice
Amount of social interaction	Isolates learners to control interaction	Frequently involves complex social interactions with participants sharing ideas, distracting each other, and so on
Characterizing the findings	Focuses on testing hypothesis	Involves looking at multiple aspects of the design and developing a profile that characterizes the design in practice
Role of participants	Treats participants as subjects	Involves different participants in the design so as to bring their differing expertise into producing and analyzing the design

Note. Adapted from Collins (1999).

developing a profile or theory that characterizes the design in practice (as opposed to simply testing hypotheses).²

One challenging component of doing educational research on design-based interventions is to characterize the complexity, fragility, messiness, and eventual solidity of the design and doing so in a way that will be valuable to others. This latter criterion implies that design-based research requires more than understanding the

²It is important to note that this contrast is not meant to deride the importance of traditional psychological methods. In fact, it is our belief that design-based research and other methods should be viewed as complementary and supportive—allowing researchers to understand more completely their claims. For example, laboratory-based researchers should ask themselves how their laboratory-based claims would benefit from further testing in naturalistic contexts and design-based researchers should be asking how their claims would benefit from more rigorous testing within laboratory-based contexts.

happenings of one particular context, but also requires showing the relevance of the findings derived from the context of intervention to other contexts. Stake (1995) referred to this type of generalization as a *petite generalization*. The anthropologist Clifford Geertz (1976, 1983) discussed the importance of work having both experience-near significance and experience-distant relevance, stating:

Confinement to experience-near concepts leaves the ethnographer awash in immediacies, as well as entangled in vernacular. Confinement to experience-distant ones leaves him stranded in abstractions and smothered in jargon. (p. 57)

Translating this perspective to design-based research, the validation of a particular design framework is not simply intended to show the value of a particular curriculum. Instead, design-based research strives to generate and advance a particular set of theoretical constructs that transcends the environmental particulars of the contexts in which they were generated, selected, or refined. This focus on advancing theory grounded in naturalistic contexts sets design-based research apart from laboratory experiments or evaluation research.

At first glance, design-based research closely resembles formative evaluation methodologies. Both are naturalistic, process-oriented, iterative, and involve creating a tangible design that works in complex social settings. The process of conducting a formative evaluation—articulating goals, operationalizing measures, examining a phenomena and understanding the consequences of its use (both intended and unintended)—is quite similar to many design-based research studies. Indeed, design-based research has been justifiably criticized for being little more than formative evaluation, even ignoring some of the recent advances made in formative evaluation. What separates design-based research in the learning sciences from formative evaluation is (a) a constant impulse toward connecting design interventions with existing theory, (b) the fact that design-based research may generate new theories (not simply testing existing theories), and (c) that for some research questions the context in which the design-based research is being carried out is the *minimal ontology* for which the variables can be adequately investigated (implying that we cannot return to the laboratory to further test the theoretical claims).

Fundamentally, formative evaluation methodologies (or even instructional design models) are about improving the value of a particular designed artifact (or a process for carrying out design), whereas design-based research is concerned with using design in the service of developing broad models of how humans think, know, act and learn; that is, a critical component of design-based research is that the design is conceived not just to meet local needs, but to advance a theoretical agenda, to uncover, explore, and confirm theoretical relationships. Although providing credible evidence for local gains as a result of a particular design may be *necessary*, it is not *sufficient*. *Design-based research requires more than simply*

showing a particular design works but demands that the researcher (move beyond a particular design exemplar to) generate evidence-based claims about learning that address contemporary theoretical issues and further the theoretical knowledge of the field.

We further illuminate this point by looking at our own work as an example. In Barab's work over the last 5 years, he and his colleagues have worked to develop various designs to support the learning of interdisciplinary content (Barab & Landa, 1997; Barab, 1999), the learning of science concepts (Barab, Hay, Barnett, & Keating, 2000), an appreciation for the practices of scientists (Barab & Hay, 2001), the emergence of web-supported communities to support teacher professional development (Barab, MaKinster, Moore, Cunningham, & the ILF Design Team, 2001), and multi-user virtual environments to support children ages 9–13 in developing their own sense of purpose as individuals, as members of their communities, and as knowledgeable citizens of the world (Barab, Thomas, Dodge, Carteaux, & Tuzun, in press). Whereas this joint commitment to research and service meant meeting the immediate needs of participants, there also existed a complementary goal of producing theory that would have relevance for researchers not involved in the initial design research (see Table 2). Table 2 reveals both the local impact of the work as well as the resultant theoretical contributions, with our argument being that design-based research requires providing local warrants for the effectiveness of the design work while simultaneously attempting to contribute to a larger body of theory. As design-based researchers, we have found it both critical and challenging to continually make both types of arguments, arguments that have both experience-near significance and experience-distant relevance. For example, in Barab's Quest Atlantis project, documenting the learning gains was a necessary part of the research agenda because it provided warrants for the broader theoretical assertions about the relationship among the constructs of playing, helping, and learning, the importance of context in learning, and the value of socially responsive design (Barab et al., in press).

In contrast to other methods focused on producing theory, the most radical shift proposed by design researchers may be the requirement that inquiry involves producing demonstrable changes at the local level. Design-based researchers not only recognize the importance of local contexts but also treat changes in these contexts as necessary evidence for the viability of a theory. Design-based research that advances theory but does not demonstrate the value of the design in creating an impact on learning in the local context of study has not adequately justified the value of the theory. As such, design-based research suggests a pragmatic philosophical underpinning, one in which the value of a theory lies in its ability to produce changes in the world. Such a system of inquiry might draw less from traditional positivist science or ethnographic traditions of inquiry, and more from pragmatic lines of inquiry where theories are judged not by their claims to truth, but by their ability to do work in the world (Dewey, 1938). Researchers looking to add method-

TABLE 2
 Characterizing Design-Based Research in Terms of the Designed Artifact
 and Resultant Theory

<i>Research Study</i>	<i>Local Impact</i>	<i>Theoretical Work</i>
Hartford Middle School project	Teacher professional development, produced curricular units, student learning and attitudinal gains	Interdisciplinary anchors as useful construct for teacher conceptualization and development of interdisciplinary units
Student apprenticeship camp	Pre–post learning gains, student attitudinal changes, positive attitude of scientists	Richer understanding of apprenticeship-type learning Characterization of differences between <i>constructivist</i> and <i>apprenticeship</i> learning environments
Virtual solar system project	Student learning gains, student collaboration	Claims about project-based learning and cognition as situated, particularly relations among learners' intentions, tools, and meaning making
Inquiry learning forum project	Participation rates, learning gains, control–experimental group attitudinal differences, interview testimonials	Richer understanding of the challenges of designing for Web-supported communities in the service of learning; Claims about the tenability of designing community
Quest Atlantis project	Pre–post learning gains, control–experimental group quality of work and attitudinal differences; interview testimonials; participation rates; chat and classroom observations	Demonstrating the interrelations of learning, playing, and helping; Richer understanding of the symbolic relations of power and play in multiuser virtual environments; Potential value of socially responsive design

ological rigor and coherent epistemological systems to design-based methodologies might benefit from further grounding in the pragmatic philosophies of Dewey and Peirce, both of whom have provided systems of inquiry rooted *not* in claims of truth, but rather in the viability of theories to explain phenomena and produce change in the world.

ADVANCING CREDIBLE ASSERTIONS

An important question that must be answered by design-based researchers is what counts as credible evidence. Schoenfeld (1992) argued that a sound methodological argument in the social sciences should touch on issues of trustworthiness, credibility, and usefulness as well as the range of contexts in which the researcher believes the assertions should extend. Whereas the first two criteria (trustworthiness and

credibility) are akin to reliability and validity but do not necessarily require the use of objective and quantitative methods for demonstrating they have been met, and the last criterion (usefulness) is somewhat akin to generalizability and external validity, we view the term usefulness as less commonly invoked when determining the strength of a researcher's claims (Dewey, 1938; Messick, 1992). It is one thing to demonstrate learning gains or show that statistical differences have been achieved; it is quite another thing to demonstrate the usefulness or consequentiality of the work. With respect to design-based research, and learning sciences more generally, this consequentiality is an essential criterion for determining the significance of a particular study. Our goal, as applied researchers engaged in doing design work, is to directly impact practice while advancing theory that will be of use to others.

The emphasis on understanding the value of a theory through its consequences on naturalistic systems also borrows from Messick's (1992) notion of evidence of consequential validity for testing. His argument is that the validity of a claim is based on the changes it produces in a given system. These changes or consequences can then be considered evidence in support of validity. Messick's original formulation of consequential validity argues that inquiry is a social enterprise and evidence for the validity of an assertion can be gathered by examining the effects of that assertion on a system; a classic violation of this principle is when standardized tests result in undesirable practices in schools and routinized, shallow learning, suggesting that perhaps standardized tests are a poor instrument for generating assertions about student achievement (Linn, 1998). Design-based research offers a mode of inquiry that embraces this notion of consequential validity, but design researchers need to be clearer about the kinds of claims they make from design experiments and the limitations of their findings. At the expense of being redundant in our argument, we believe that while demonstrating local consequence and utility is necessary it is not sufficient—*design scientists must draw connections to theoretical assertions and claims that transcend the local context.*

One of the central ideas in the scientific paradigm is replicability; however, because design-based researchers cannot (and may not want to) manipulate cultural contexts, it becomes difficult to replicate others' findings (Hoadley, 2002). Therefore, the goal of design-based research is to lay open and problematize the completed design and resultant implementation in a way that provides insight into the local dynamics. This involves not simply sharing the designed artifact, but providing rich descriptions of context, guiding and emerging theory, design features of the intervention, and the impact of these features on participation and learning. Narrative, as one way of making sense of design-based research, is a historical method that involves conveying a series of related plots and describing the temporal unfolding of the design over time (Abbott, 1992; Mink, Fay, Golob, & Vann, 1987). A core challenge in building narrative is what historiographers refer to as the "central subject problem" in which the boundaries of the case itself are delimited (Hull, 1975). Although in some instances the case may have clear boundaries,

more often than not a crucial difficulty lies in “drawing boundaries around the central subject given the continuous character of the social manifold” (Abbott, 1992, p. 63). These boundaries are always fuzzy, with the properties of the cases and the design work passing through multiple transformations over time.

It is the unpacking of these transformations, describing what the case endures, and relating these changes to underlying theory that philosophers refer to as the “colligation” problem. The important and somewhat disheartening point with respect to this problem is an appreciation of each event being complex, enduring multiple transformations, having multiple antecedents, and resulting in a myriad of consequences (Isaac, 1997). This led Abbott (1992) to discuss a case as a sequence of major turning points (kernels) and sets of situational consequences flowing from these kernels. As such, a fundamental challenge in presenting design narratives lies in uncovering these events so that the reader understands their complexity but doing so in a way that lends itself global relevance while at the same time meaningfully capturing the dynamic unfolding of the phenomena.

Design-based research involves more than simply describing the design and the conditions under which it changed. Cobb et al. (2003, p. 10) suggests that “design experiments are conducted to develop theories, not merely to empirically tune ‘what works.’” diSessa and Cobb (this issue), along similar lines, argue that design-based research should involve theory work, treating the design platforms as contexts through which theory may be advanced. This type of work is iterative in nature, with the long-term commitment being to continually refine theoretical claims so as to produce what diSessa and Cobb refer to as “ontological innovations.” They suggest that design-based research allows for the production and testing of theory that can be used to generate, select, and validate specific design alternatives; revealing how various designs predicated on different theoretical assumptions are differentially consequential for learning. In this way, the validation of a particular design framework is not simply intended to show the value of a particular curriculum but results in the advancement of a particular set of theoretical constructs.

Another core challenge in carrying out design-based research arises given the joint role of the researchers as designer and researcher. Design-based researchers are not simply observing interactions but are actually “causing” the very same interactions they are making claims about. Barab and Kirshner (2001) wrote:

The goal of these researchers/educators/designers moves beyond offering explanations *of*, to designing interventions *for*. In fact, and consistent with pragmatists such as Dewey, Pierce, and James, to some degree it is the latter functional constraint that constitutes what is a useful explanation of. (p. 4)

This pragmatic approach to research may be valuable in that it creates theory that serves local practice, but it also produces challenges for design-based researchers.

How do we account for the role of the researcher in the design experiments and the associated threats to validity that they bring with them? If a researcher is intimately involved in the conceptualization, design, development, implementation, and researching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge. Researchers working in schools often face difficult ethical choices. Do they stand idly by and watch a teacher struggle to use their curricula, or do they intervene providing additional support? Do researchers share stories of struggling students with teachers and allow them to change instruction accordingly, or do they play a “hands-off” role, minimizing their impact on classroom practices? Ironically, although Brown (1992) introduced design experiments in part as a method for developing a richer appreciation of variables as they occurred in naturalistic contexts, her role as context manipulator may have undermined the credibility of her claims. In other words, each systematic alteration of the designed context potentially contributes to the findings and claims being more artificial and less naturalistic.

In Cobb et al.’s (1999) “teaching experiment” approach, this problem of intervention is turned on its head so that issues that arise in the environment are to be accounted for and integrated into existing theory. It is through understanding the recursive patterns of researchers’ framing questions, developing goals, implementing interventions, and analyzing resultant activity that knowledge is produced. Rather than remain detached from the research context, researchers are implored to intervene where possible, using interventions as opportunities to examine core theoretical issues and explore learning. Critics will observe that such interventions “taint” the research context. Cobb argued that effective instructional models develop through these interventions, and it is through subsequent refining and testing that effective models are developed and deployed in other contexts. In this way, each new application is an extension of the theory as its specific characteristics are situated in local dynamics.

It seems that the basic methodological concern for the independence of the researcher and the learning environment is not operative in design-based research, fundamentally challenging the credibility of assertions generated through design research. However, such systematic experimentation is what makes design-based research a potentially useful methodological approach for learning scientists. Therefore, it is the responsibility of the researcher to draw on methodological practices consistent with other qualitative methods (e.g., see Glaser & Strauss, 1967; Lincoln & Guba, 1985) to convince others of the trustworthiness and credibility of claims being advanced. It is also the responsibility of the design-based researcher to remember that claims are based on researcher influenced contexts and, as such, may not be generalizable to other contexts of implementation where the researcher does not so directly influence the context.

Fishman et al. (this issue) further problematized the issue by suggesting that any classroom context, even without the manipulations of a design researcher, is

impacted by the systemic constraints in which it is nested, thereby making the generalizability of any naturalistic findings highly suspect. We believe that contexts are never without agency; there are always teachers, administrators, students, and community members creating context and, therefore, local adaptability must be allowed for in the theory. The goal is not to “sterilize” naturalistic contexts from all confounding variables so the generated theory is more valid and reliable. Instead, the challenge is to develop flexibly adaptive theories that remain useful even when applied to new local contexts. This potential of flexibly adaptive theory does not result because the theory was somehow generated in a context that was free of confounding situational variables, but rather, because the theory is supple enough to maintain its robustness even in the context of changing situational variables. Theory generated from design-based research, from this perspective, must strike a balance between refinement and adaptability.

DEFINING THE NATURALISTIC CONTEXT

A core part of design-based research as applied work involves situating the work in “naturalistic contexts.” Whereas most learning science researchers would agree with this commitment, the boundaries of *context* and what constitutes *naturalistic* may prove elusive. For example, Barab, Hay, Barnett, and Keating (2000) conducted design-based research in a university classroom context, iteratively refining course materials each semester so as to advance a participatory learning framework that was conceptually rich and theoretically grounded. However, their focus was on the individual classroom and not the larger system through which university courses occur. As such, although the work resulted in meaningful pedagogical practices, the theory did not adequately take into account the constraints that shaped the local context of the intervention and, therefore, resulted in theory with limited experience-distant relevance. In fact, even in the initial context of innovation where they demonstrated learning gains and had interested stake holders, the course was discontinued because it was not a profitable model (courses of $n = 20$ as opposed to the more traditional laboratory courses of $n = 100\text{--}150$) and required a certain type of instructor to succeed.

One might argue that within this large university context, doing design research on a single class without simultaneously addressing issues in the broader College of Arts and Sciences and University context constituted an impoverished and fundamentally flawed definition of design research. It is this critique that underlies the final core article of this special issue. Fishman et al. (this issue) argue that most design-based research does not explicitly address systemic issues of usability, scalability and sustainability and that “this limitation must be overcome if research is to create usable knowledge that addresses the challenges confronting technology innovations when implemented in real-world school contexts” (p. 43). They suggest a conception of design-based research that includes research on innovations in the context of systemic reform and that explores usability in terms of “gaps” between the