Design-based research (DBR) is used to study learning in environments that are designed and systematically changed by the researcher. DBR is not a fixed “cookbook” method; it is a collection of approaches that involve a commitment to studying activity in naturalistic settings, with the goal of advancing theory while at the same time directly impacting practice. The goal of DBR (sometimes also referred to as design experiments) is to use the close study of learning as it unfolds within a naturalistic context that contains theoretically inspired innovations, usually that have passed through multiple iterations, to then develop new theories, artifacts, and practices that can be generalized to other schools and classrooms. In describing design-based research, Cobb, Confrey, diSessa, Lehrer, and Schauble stated:

Proto-typically, 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. (Cobb et al., 2003, p. 9)

This iterative design process allows the researcher to move beyond simply understanding the world as it is, and involves working to change it in useful ways with the broader goal of examining how these systematic changes influence learning and practice (Barab & Squire, 2004). This innovative aspect of design-based research makes it a useful methodology for advancing new theory and practice.

One way of understanding the focus of design-based research is in terms of Pasteur’s Quadrant (Stokes, 1997; see Figure 8.1). In this quadrant model for characterizing scientific research, the upper left-hand cell consists of basic research for the sole purpose of understanding without an eye toward practical use. The lower right-hand cell consists of research that focuses solely on applied goals without seeking a more general understanding of the

This research was supported in part by a grant from the Bill and Melinda Gates Foundation. Also, special thanks to Alan Amory for his valuable feedback, especially because he brought an international perspective to the manuscript. Special thanks also to Alan Gershenfeld, whose valuable feedback is evolving my thinking around what it means to carry out design-based research such that it is likely to bring about scaled and sustained impact.
The Cambridge Handbook of the Learning Sciences

Second Edition

Edited by
R. Keith Sawyer
Figure 8.1. Quadrant model of scientific research.

<table>
<thead>
<tr>
<th>Consideration of Use</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure basic research (Bohr)</td>
<td>Yes</td>
<td>Pure applied research (Edison)</td>
</tr>
<tr>
<td>Use-inspired basic-research (Pasteur)</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

phenomena. While Stokes intentionally left blank the empty bottom left cell, Reeves and Hedberg posited that much of educational research belongs in this sterile quadrant that addresses neither theory nor practice (2003, p. 265). This chapter is primarily concerned with the upper right-hand cell, where DBR is located, in which the focus is on advancing “the frontiers of understanding but is also inspired by considerations of use” (Stokes, 1997, p. 74).

Barab and Squire argued that “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)” (Barab & Squire, 2004, p. 6). The design-based researcher must demonstrate local impact while at the same time making a case that this local impact can be explained using the particular theory being advanced.

Design-based research involves more than simply reporting outcomes: DBR moves beyond descriptive accounts to offer what Gee (2013) refers to as “storied truths” from which others can gain process insights that usefully inform their work. Storied truths, while bound to a particular context, are based on a level of reflexive thinking in relation to grounded warrants (Toulmin, 1958; also see Andriessen & Baker, Chapter 22, this volume) that shift the underlying claim from personal sentiment or informed opinion to a warranted argument that is meaningfully tied to the world. Such sharing involves methodological precision and rich accounts so that others can judge the value of the contribution, as well as make connections to their own contexts of innovation. Critics of DBR tend to be advocates of controlled experimental methodologies. These critics argue that DBR does not provide empirical evidence to ground claims; at best, it can provide formative insights that must then be tested through more controlled experimentation. In addition, many academic demands encourage researchers to make use of the “proven” methodologies associated with positivist science, including controlled experiments (Engeström, 2011, p. 598). In this chapter, I argue that design-based research is not simply a precursor to more rigorous, experimental research, but is a form of research that can provide rigorous empirical grounding to theoretical claims and explanations and that can be more illuminative and useful to others because of its emphasis on exposing methodological mechanisms, “petite general challenges and strategies for n...
exposing mechanisms and its articulation of the conditions through which these mechanisms were realized. A well-presented and carefully conducted design narrative has the potential to support what Stake (1995) referred to as “petite generalizations”; that is, work that provides others insights into the challenges and opportunities that might emerge in their own work, as well as strategies for navigating these effectively.

According to educational researchers who use DBR – and contrary to the arguments of those pushing for experimental designs as the gold standard – the messiness of real-world practice must be recognized, understood, and integrated as part of theoretical claims if the claims are to have real-world explanatory value. From this perspective, experimental designs, those that examine teaching and learning as isolated variables within laboratory or other artificial contexts, will necessarily lead to understandings and theories that are incomplete. A key argument in favor of DBR is that demonstrating value in context should be a key component of the theory validation process empirical researchers undertake. Experimental studies can certainly validate theories, but simply demonstrating a variable is significant, while useful as part of the validating story, may be less effective than are rich examples and case narratives for informing how to implement a particular variable or theory within the context of real-world practice. Within learning environments, so called confounding variables necessarily occur and must be taken into account (not controlled) if the findings are to be relevant to practitioners (also see Greeno & Engeström, Chapter 7, this volume). Context is not simply a container within which the disembodied “regularities” under study occur, but is an integral part of the complex causal mechanisms that give rise to the phenomenon under study (Maxwell, 2004).

If researchers only study that which takes place in controlled conditions, they run the risk of developing artificial meanings and interactive dynamics that are so free of contextual realities that any interpretations are suspect with respect to informing real-world practice. Because learning scientists are committed to producing change in real-world learning environments, learning sciences research often occurs in naturalistic contexts and involves confounding variables, political agendas, and multiple alternative hypotheses, and includes rich descriptions of the conditions through which the research was conducted. Given the pragmatic focus of DBR, demonstrating the potential of the intervention to have productive impact at a particular site is key to the methodological process, as well as to justifying the work more generally. However, and while showing local gains is an important element of DBR, the focus is simultaneously on developing a design and generating new theory, with local impact being an important component of the validation process. Barab and Squire stated:

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. (Barab & Squire, 2004, pp. 5–6)

To be clear, an essential element of learning sciences research is that it moves beyond observing the world as it is, and actually involves systematically engineering the contexts of study in ways that allow for the generation and advancement of new theory (Barab & Squire, 2004). However, the task of crediting the underlying theory as being responsible for the observed findings is especially challenging given the commitment to researching the designs in naturalistic contexts – so much easier to hold most variables constant when it comes to making causal claims. To further complicate the process, the learning environments DBR studies are often developed by the researchers who are studying it and advancing theoretical claims based on it. The methodology of design-based research emerged specifically in relation to these complex issues, but with the commitment that such complications are necessary when doing research on underlying mechanisms. This is because of the core assumption that the implementation situation will necessarily interact with and co-determine the realization of an intervention, thereby making claims based on more constrained situations such as the laboratory only minimally useful for understanding implications of the underlying theory and for scaling impact to naturalistic contexts.

**Setting the Stage**

Design-based research is frequently traced back to 1992 when Ann Brown (1992) and Allan Collins (1992) introduced a new methodological approach for conducting research and design work in the context of real-life settings. In complex learning environments, it is difficult to test the causal impact of specific independent variables on specific dependent variables using experimental designs. DBR deals with complexity by iteratively changing the learning environment over time – collecting evidence of the effect of these variations and feeding it recursively into future designs (Brown, 1992; Collins, 1992). DBR is especially useful for understanding the underlying reasons why something is happening (Shavelson & Towne, 2002) or under which conditions a particular interaction or occurrence could happen. Because DBR takes place in naturalistic contexts, it also allows for the identification and examination of multiple interacting variables, thereby providing systems-level understandings.

A second motivation for DBR is the belief that the “factoring assumption” of experimental psychology is not valid in learning environments (Greeno & Engeström, Chapter 7, this volume). The factoring assumption is the assumption that we can analyze individual cognitive processes apart from any particular context. Instead, a core assumption of learning scientists is that the individual and the learning environment are inseparable, with the...
g that addresses local contextual particulars (Brown, Collins, & Duguid, 1989; Kirshner & Whitson, 1997; Salomon, 1993). Lave argued:

There is a reason to suspect that what we call cognition is in fact a complex social phenomenon. The point is not so much that arrangements of knowledge in the head correspond in a complicated way to the social world outside the head, but that they are socially organized in such a fashion as to be indivisible. “Cognition” observed in everyday practice is distributed – stretched over, not divided among – mind, body, activity and culturally organized settings which include other actors. (Lave, 1988, p. 1)

Cognition, rather than being a disembodied process occurring in the confines of the mind, is a distributed process spread out across the knower, the environment, and even the meaning of the activity in context (Salomon, 1993). Similarly, knowledge is not abstract and universal, but rather is bound up in numerous contexts and should always be considered “storiied” – storiied being an empirical constraint with respect to the “truthness” of knowledge; an epistemological constraint with respect to how the knowledge should be framed in terms of learning; and a pragmatic constraint in terms of whether the knowledge functions in an impactful manner with respect to its lived impact in the world (Gee, personal communication, 2013). From a situative perspective, studying a phenomenon such as motivation, metacognition, or even learning in a laboratory context might result in scientifically reliable but consequentially limited understandings that have little generalizable value in real-world contexts (Greeno & Engeström, Chapter 7, this volume).

In addition to understanding learning in complex environments and engineering new learning environments, DBR accomplishes a third goal: it improves learning for those participants in the study. This is valuable to learning scientists, because a core commitment of learning sciences research is that the work will have local impact. A challenge then becomes that of generalizing the local findings, or scaling up; and this requires understanding the contextual dynamics that surround the implementation of a complex learning environment in such a way that the findings can inform implementation in other contexts. The goal is to advance theory-in-context: the conviction that the theory is always situated in terms of local particulars. Accounts of DBR should describe both the theory and the particulars in a way that allows others to understand how to recontextualize the theory-in-context with respect to their local particulars.

One way of understanding the relations among theory, design, and implementation is in terms of Dewey’s (1915) notion of praxis; the act of translating theory into action. For Dewey, praxis was not a unidirectional process, but a transactive one involving inquiry and through which theory and practice mutually inform each other. Confrey, commenting on the process of praxis, stated that Dewey “recognizes that in the beginning, there is only the indeterminate, which undergoes a transformation through a problematic to
a hypothesis which by means of the activity of inquiry is transformed to a
determinate situation producing a set of knowledge claims” (Confrey, 2006,
p. 139). In this way, theory can come from action just as action can come
from theory. DBR can be thought of as a form of praxis, with design/imple-
mentation being the practice. Dewey’s notion of praxis as transactive further
implies that in practice the theory (and design) will flex according to local
particulars, possibly resulting in lethal design mutations even in the context
of reasonable theory. Confrey, along similar lines, suggests that DBR results
in explanatory frameworks that “cannot predict the outcomes precisely, for
each realization is in effect unique, but does yield tendencies that can guide
decision-making and the settings of parameters” (Confrey, 2006, p. 139). As
such, an essential part of advancing theory-in-context is to communicate
the theory as well as the contextual particulars through which it is realized in
practice – a process that DBR is particularly effective in illuminating.

### Defining Design-Based Research

Conducting DBR requires posing significant questions that can be
investigated empirically, linking research to theory, providing a coherent and
explicit chain of reasoning, demonstrating impact, disclosing research data
and methods to enable and encourage professional scrutiny and critique, and
employing methodological practices that are deemed credible and trustworthy
and that result in useful claims (Shavelson, Phillips, Towne, & Feuer, 2003). Because this work takes place in naturalistic contexts and involves the
systematic tweaking of theoretically inspired aspects of the learning environ-
ment, this research can offer insights into why and how a particular intervention works. Such theoretical and methodological rigor is necessary if DBR
is to evolve into an accepted methodology advancing theoretical constructs
and designs that are of use to others. Collins and colleagues (1992; Collins,
Joseph, & Bielaczyc, 2004) posit seven major differences between traditional
experimental psychological methods and DBR, to which I add an eighth dif-
dference, the goal of research (see Table 8.1).

Figure 8.2 characterizes the core elements (design, theory, problem, natu-
ralistic context) of DBR, and visually represents how each of these components transact with the others such that the design is predicated on theory
and the strength of the theory is bound up with how the design addresses
the problem. It is not simply that DBR happens in naturalistic settings but,
rather, such research transacts with these settings such that the design, the
problem, and even the theory are fused with these settings in ways that are
not easy to disentangle. Finally, DBR usually involves multiple iterations or
what Collins (1992) refers to as progressive refinement, with each iteration
providing a further refinement of the design in order to test the value of the
innovation and, hopefully, stimulating the evolution of theory.
Table 8.1. **Contrasting DBR with laboratory experimentation in terms of elements that illuminate key differences**

<table>
<thead>
<tr>
<th>Element</th>
<th>DBR</th>
<th>Psychology experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of research</td>
<td>Real-world learning environment</td>
<td>Laboratory</td>
</tr>
<tr>
<td>Complexity of variables</td>
<td>Multiple types of dependent variables</td>
<td>A few dependent variables</td>
</tr>
<tr>
<td>Treatment of variables</td>
<td>Not all variables of interest are known in advance; some emerge during the study</td>
<td>A few variables are selected in advance and remain constant during the study</td>
</tr>
<tr>
<td>Unfolding of procedures</td>
<td>Research procedures are flexible and evolve during the study</td>
<td>Fixed procedures are used</td>
</tr>
<tr>
<td>Social interaction</td>
<td>Complex social interactions with collaboration and sharing</td>
<td>Isolation of individuals</td>
</tr>
<tr>
<td>Reporting the findings</td>
<td>Describing design in practice</td>
<td>Report on whether hypotheses were supported</td>
</tr>
<tr>
<td>Role of participants</td>
<td>Experimenter and participants are active and influence the design of the research</td>
<td>Experimenter should not influence the subject and subjects do not influence the design</td>
</tr>
<tr>
<td>Goal of research</td>
<td>Produce impact and explain mechanism</td>
<td>Validate theory</td>
</tr>
</tbody>
</table>

Figure 8.2. **General characterization of design-based research.**
It requires rigorous methods to demonstrate the linkages between theory and design, between design and problem, between theory and problem, and between successive iterations of the design; rigorous methods that make convincing arguments (although they rarely totally rule out alternative explanations). Confrey (2006) suggested that in research, evidence of methodological rigor comes from three sources:

1) the experimentation/investigation has itself been adequately conducted and analyzed;
2) the claims are justified, robust, significant relative to the data and the theory, and subjected to alternative interpretations; and
3) the relevance of the claims to the practices of education is explicit and feasible.

The rigor comes from principled accounts that provide logical chains of reasoning and prove useful to others. Design-based researchers must employ rigorous methods if they wish others to believe (and benefit from) the theoretical claims they wish to advance.

A challenge is to describe the findings in a way that allows others to understand how to recontextualize them with respect to their local particulars. A second challenge is that unlike experimental design, it becomes difficult to rule out alternative explanations. Given these complications, how can the design-based researcher convince others of the credibility of the claims? More often than not, this requires a balance of qualitative and quantitative data, although always taking place in rich naturalistic contexts. Even when conducting experimental comparisons among groups, the researcher is interested in unpacking mechanism and process and not simply reporting that differences did or did not occur. Opening up the black box of theories-in-context reveals complex interactions that cannot be usefully disentangled and reductively analyzed in terms of component variables. Instead, it is necessary to communicate these theories in their full contextual splendor, illuminating process insights while at the same time demonstrating local outcomes. Making convincing arguments from DBR research is challenging and involves complex narratives (Abbott, 1992; Mink, Fay, Golob, & Vann, 1987) and building rich models of interaction (Lesh & Kelly, 2000) — not simply reporting outcomes. Later in this chapter, I expand on some of these challenges, especially when the goal is to shift from theoretical validation to actually producing impact.

### Changing Designs to Engineering Change

**From Inputs to Outputs to Meaningful Outcomes**

McKinsey and Company (2004) distinguished *outputs* — or the direct and tangible products from the activity — from the more significant *outcomes*, referring to intervention results in terms of significant changes in the environment that are expected to persist. Outputs are the direct and measurable products of an activity, while outcomes are the more significant changes in the environment that are expected to persist.
between theory and that make conative explanatory-methodological
different data and the
is explicit and
logical chains of
must employ (from) the theo-
others to under-
particulars. A difficult to rule
can the design-
ns? More often
data, although
ducting exper-
d in unpacking
nces did or did
eveals complex
alyzed in
municate these
s insights while
vincing argu-
pless narratives
ng rich models
omes. Later in
hen the goal is

the direct and
ant outcomes,
referring to the more lasting changes that occur over time following an
intervention. More generally, paying careful consideration to what business
refers to as the “return on investment” might prove useful in ensuring learning
scients do not overly focus on theory building research at the expense
of scalable and sustainable impact. If we are careful to consider what are the
ecessary inputs to enact the underlying theory of change, in relation to the
roduction of outputs and outcomes (see Figure 8.3), it would help us to
avoid “boutique” research endeavors – that is, research that results in war-
ranted claims and theoretical arguments that cannot be generalized to other
classrooms and schools. A theory of change is an articulation of the under-
ling mechanisms and processes through which a complex organizational
change is expected to occur. A core task of DBR involves the instantiation
of the theory of change within a particular designed intervention, informed
by previous research and consistent with an underlying set of theoretical
assumptions.

Another potential problem of DBR, highlighted by Figure 8.3’s mapping
of inputs to theory of change to outputs to outcomes, is the potential for
undesirable local outcomes or consequences – and this would be an even
worse outcome than non-scalable theory. Outputs are the direct results of
program activities, and can be considered closely connected with respect
to causal connections to the program activities. They are often immediately
measurable. More complex are outcomes, which are not usually direct
and are considered to be longer-term effects expressed in the future. They
require more complex causal connections, and are expected to reveal them-
selves in situations independent of the intervention itself. So, for example,
adding fertilizers to soil can directly increase crop production, but do not
ecessarily guarantee and can even be at odds with self-reliance outcomes.
Or, as another example, behavior modification might have the immediate
output of increasing or decreasing performance, but runs the risk of nega-
tively affecting such change with respect to longer-term outcomes. Barrett,
referring to unintended consequences of food dependency, discusses “the
undesirable aspect, ‘negative dependency,’ [that] arises when meeting current
needs comes at the cost of reducing recipients’ capacity to meet their own
basic needs in the future without external assistance” (Barrett, 2006). I argue
that design-based researchers must be responsible for the outcomes of their

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According to Connell and Klem (2000), a theory of change should be plausible (the logic
makes sense), doable (implementable with available resources), testable (outcomes can be
assessed and mechanism can be analyzed), and meaningful (the outcomes are worth the
inputs).
work, including such unintended outcomes; considering the unintended consequences of advancing theoretical claims or of particular pedagogical approaches should become a key tenet of such research.

Traditionally, much of the educational psychology and cognitive sciences research from which learning sciences emerged (Brown, 1992) framed outputs in terms of immediate and what might be referred to as sequestered learning and assessment; that is, learning that can be demonstrated without the aid of others or tools. This focus on more immediate and sequestered learning outputs, in fact, has dominated how we evaluate learning. The problem is that when one optimizes system performance for maximizing outputs it often occurs at the expense of outcomes. So, for example, one might argue that schools have been optimized for standardized test performance (an output), and this potentially comes with a cost in that teachers and textbooks end up stripping so much context out to be more efficient with respect to test preparation, that they end up alienating real-world application (an outcome). Schools are often criticized for such output optimization with the more problematic concern that increasing performance on standardized test scores has come at the detriment of achieving more general outcomes such as passion for knowledge, use-inspired understanding, and critical thinking.

Critical theorist Peter McLaren specified "the ability to read and write in no way ensures that literate persons will achieve an accurate or 'deep' political understanding of the world and their place within it" (McLaren, 1988, p. 319). It is time to consider these broader outcomes, using DBR to help uncover at what cost our learning gains come and how our work might be even more influential if we were to consider the immediate outputs and how they were helping achieve the longer-term and more impactful outcomes. Outcomes could be at the level of the individual, differentiating between learning gains and inciting within the learner a passion for knowledge, or a commitment to use the content learned especially when not required to do so (Barab, Thomas, Dodge, Squire, & Newell, 2004). Beyond individual change, learning sciences research also takes place within a broader ecosystem, and it is essential that we consider the implications of our research with respect to the implementation contexts in which our work must scale – especially the changes required to have an infrastructure for successfully implementing the work. The importance of understanding the relations among our designs and the ecosystems in which they are implemented is elaborated in the next section.

**From Designs to Services to Optimized Systems**

A key component of design-based research is that the research takes place in relation to a theoretically inspired design – whether of a lesson, a product, a policy, a system, or even a program – as long as some theoretical inspiration exists that informed the design decisions and that, if the implementation succeeds, will: "principle. Prot lesson, policy, consider the design is bound up w to usefully supp services (not proc the design eng situativity the from those cor of design-base ongoing optim 

If design is: discuss context motivated Pen implementation which they arg of practice fro iterative, collab to both classro and (d) a conce (Penel et al., 2 in naturalistic c be considered a better able to n greater challenge innovation that site that is not ( 2011), but posit Learning sci rooms, scho sibility for the these facilitator dashboards, wh interface, can a should not stud will be integrat tion facilitators the design in sit to spend time w
succeeds, will strengthen the underlying meaningful assumption, theory, or principle. Problematically, it has been quite common to treat the designed lesson, policy, or program as a fixed object. In contrast, I have come to consider the design itself less of an object and more of a "service" whose fidelity is bound up within an ecosystem that does (or does not) have the capacity to usefully support the design in situ. We must consider our designs as services (not products) whose effectiveness is always integrated with how well the design engages the ecosystem to optimize its success. Similar to how situativity theorists have challenged the notion of knowledge as separate from those contexts in which it functions, I have begun to see the "design" of design-based research as a fundamentally situated "service" that requires ongoing optimization and support.

If design is a situated service, it is difficult (if not theoretically naïve) to discuss contexts as somehow separate from the design. This is, in part, what motivated Penuel, Fishman, Cheng, and Sabelli's discussion of design-based implementation research (see Penuel and Spillane, Chapter 32, this volume), which they argue has four key elements: "(a) a focus on persistent problems of practice from multiple stakeholders' perspectives; (b) a commitment to iterative, collaborative design; (c) a concern with developing theory related to both classroom learning and implementation through systematic inquiry; and (d) a concern with developing capacity for sustaining change in systems" (Penuel et al., 2011, p. 331). From this perspective, DBR does not take place in naturalistic contexts, but rather the design and the context together should be considered as part of a distributed ecosystem – with some contexts being better able to realize the effectiveness of a particular design. This is an even greater challenge if the motivation underlying a design is to introduce an innovation that is paradigm changing, in that one needs an implementation site that is not only "tolerant" of disruptive innovations (Christensen, 2006, 2011), but positioned to maximize their potential.

Learning scientists often distribute their designs to organizations (classrooms, schools, or districts) that may include a facilitator who takes responsibility for the ongoing optimization of the design-in-context. To support these facilitators, many new educational software products include teacher dashboards, where teachers can monitor student learning, and through this interface, can adjust the system parameters to better support learning. We should not study our designs independent of the ecosystems in which they will be integrated; instead, we should engage stakeholders and implementation facilitators as collaborators whose potential actions can become part of the design in situ. In this type of research, a necessary step is for the researcher to spend time with facilitators nested within potential ecosystems – not as

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2 In the commercial gaming industry, designers often build the game such that it can be continually optimized in relation to data from "community managers" who employ various methodologies to better understand player/community needs and ensure that designers can optimize player experience.
subjects to be analyzed, but as partners whose insights and functioning are an essential system component. Over time, through design-based implementation research, these insights can result in the development of implementation tools; and these implementation tools should allow the facilitator to remain a dynamic system element able to continually optimize the effectiveness of the intervention. Theoretically and practically, the design, the system, the culture, the stakeholders, and the participants collectively represent the implemented experience with the design and underlying theory each needing to account for these elements in any description.

From Stories to Truths to Storied Truths

Design-based research is a powerful methodological framework for producing usable theory that can be implemented to generate enhanced outputs and outcomes. Although demonstrating such value is an important validation of the success of the intervention, the research will not be completely successful unless the demonstrated value can be explained through some theoretical conjecture about what caused this change. Therefore, a key part of DBR involves unpacking the mechanism underlying the change, in an effort to reveal what Gee (2013) referred to as storied truths. It is in this unpacking of the underlying cause, the realizing mechanism, where one transforms the local story into an argument that has generalizable value to others who care about the underlying lessons even if not in the particular case. DBR methodology is uniquely well suited to this goal, because it is especially effective at uncovering and illuminating realizing mechanisms. Experimental methodologies are able to identify that something meaningful happened; but they are not able to articulate what about the intervention caused that story to unfold. DBR can articulate the underlying mechanism as a storied truth that has both what Geertz (1976) referred to as experience-near meanings to the local story, and at the same time, experience-distance significance to others interested in leveraging the core mechanics or assumptions in their own work.

A theory or truth is powerful if it has the ability to transcend the particular, if it is based on general principles independent of any specific instance. To be powerful in this way, the outcome of DBR must transcend the specific case, regardless of how seductive one may find a particular story. Otherwise, such stories would accumulate as disconnected anecdotes rather than building toward a growing understanding of learning and of learning environment design. One risk is that a story's meaning and use remains forever tied to the instances in which it does work; an opposed risk is that to treat it as otherwise is to leave the theory formless and, therefore, unable to impact the world in which its utility is realized. This creates a paradox, one that I believe is in part solved by always discussing theory in relation to the world. I am arguing that a theory is not a truth independent of the world, but rather a storied truth bound up in the world. Such a
position supports the idea that “people not only constantly transform and create their environment; they also create and constantly transform their very lives, consequently changing themselves in fundamental ways and, in the process, gaining self-knowledge. Therefore, human activity – material, practical, and always, by necessity, social collaborative processes aimed at transforming the world and human beings themselves with the help of collectively created tools – is the basic form of life for people” (Stetsenko, 2005, p. 72).

Storied truths are built through a process of reflective action, an “interactive conversation with the world” (Gee, 2013, p. 72). In this sense, a storied truth is grounded in actual happenings and not born simply of conjecture. It is through this grounding that any storied truth has value, and if all theories are storied truths, then it is necessary to contextualize any theoretical claim as part of advancing theory. This contextualization is both illuminative, in that such a grounded account helps to further articulate the theory, and also necessary in that it more clearly specifies the necessary conditions through which the storied truth potentially operates. In a very real way, a storied truth lives and is bound in the story itself; at the same time, if properly outlined, it can be made relevant to other stories. Here is where our notion of a storied truth has methodological resonance with Stake’s (1995) notion that a well-presented and carefully conducted design narrative has the potential to ground “petite generalizations.” This grounding occurs because of the design-based researcher’s ability, if not insistence, to continually connect the particulars to the general and versa.

A storied truth that is generated from a particular study is powerful, especially to the extent that others see value for their own work. But it is still a particular case. Bringing about change involves stringing together multiple storied truths, some of which are observed, some of which are engineered, and some of which might have been simply aspirational. For Latour (1987), a sociologist of science, truths are not found but made, and the making of truth is a complex process that involves good research but also the assembling of allies and an enabling context through which the claims are seen to be of value. Central to Latour’s assertions was the notion that the origin of a truth is actually distributed across time and involves certain moves by the scientist and certain moves by the community with the “cause” of the truth being a dialectic among multiple nodes and links that collectively constitute a truth-making network. Each of the moves, operationalized as nodes and links, are assembled as allies and contextualized in relation to the broader network. This process of making a truth is both intentional and emergent, with the important point being that any one particular and contextualized finding does not constitute a general claim – even, I argue, a storied one – it is here where Glaser and Strauss (1967) discussed the need to “saturate” the theory by building multiple grounded accounts with overlapping claims.
Conclusions and Discussion

Educational researchers have been using design-based methods to develop powerful technological tools, curricular interventions, and especially theory that can be used to improve the teaching and learning process (Bransford, Brown, & Cocking, 2000; Design-based Research Collective, 2003). Further, in contrast to controlled experimental methodologies, these “design experiments” have lent rich insight into the complex dynamics through which theories become contextualized. At the core of this design-based work is the conviction that because these innovations are informed by a particular theoretical perspective, the continual testing and refinement of what works can inform theory that has close resonance to its practical utility. However, and somewhat ironically, while Brown (1992) and Collins (1992) introduced design experiments as a method for understanding learning and developing theory within naturalistic contexts, when learning scientists manipulate learning environments while conducting their research, it may actually undermine the credibility of the claims being made (because they are not objective observers of existing learning contexts). Therefore, in addition to the challenge of working in complex situations, learning scientists face the challenge of justifying that their claims apply generally to other contexts of learning, even though at some level they are responsible for producing the very claims on which they are reporting.

Critics of such research further argue that any interpretation not generated using an experimental methodology can at best provide formative insights that must be then tested through more controlled experimentation. If this is true, then even if learning scientists present rich accounts of learning as it unfolds in complex contexts, they will have a difficult time convincing policy makers, teachers, and other researchers of the theoretical and practical value of our work (Levin & O'Donnell, 1999). It is our responsibility as researchers in this field to address, not dismiss, the concerns of these various parties. If we are going to close the credibility gap between learning scientists and policy makers (as well as colleagues arguing for the primacy of “scientifically based research,” by which they mean controlled experimental designs), we need to invest ourselves in changing public opinion with respect to what counts as evidence and in becoming more sophisticated in our methodological prowess. We have the Herculean task of grounding our theory, supporting the development of an innovation, implementing this in a naturalistic context, collecting and analyzing data in rigorous ways, and reporting all of this in a way that will convince others of the local impact of our work while at the same time showing its experience-distant value.

In this chapter, I began by restating key learning sciences assumptions. I augmented these with key challenges that emerged as the work has evolved from small “r” research focused on one study to building a large “R” research framework with the idea of designing for change. This began with
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da discussion of the differences between outputs and outcomes, highlighting the importance of considering the larger implications of the work beyond the more traditional outputs of learning gains as documented on standardized tests. Along these same lines, Torres emphatically argued that we must "debunk two educational myths of liberalism that have become more suspect at the end of the century than ever before: First, the notion that education is a neutral activity, and second, that education is an apolitical activity" (Torres, 1998, pp. 7–8). An acknowledgment of unintended consequences of even well-motivated work points to the need for broader consideration, a reflective process that occurs when one begins to consider enhancing outcomes and not simply maximizing outputs.

Situating the work in the broader implementation context (Penuel & Spillane, Chapter 32, this volume), I argued that the implementation context needs to be considered a core part of design-based research, not simply a place where it occurs. This involves the reconceptualization of designs not as products, but as services whose success is partly bound up in the way they support ongoing optimization by local stakeholders during the implementation process. Thus the implementation context is not simply a space in which one "tests" the design, but is a fundamental design component – one that in traditional research would be an independent variable or a moderating variable. This is consistent with Engeström's (2011) critique of DBR in which he suggests that the unit of analysis is vague; that such research is linear and excludes practitioners, students, and users; and remains unaware of open-ended social innovation. As one broadens the unit of analysis to be the design in situ, so must the resultant theoretical claims shift from abstracted theory to storied truths. Storied truths are resonant with and warranted within the way they are realized in the natural world, with the responsibility of the researcher being to provide a rich enough accounting such that the reader can make what Stake (1995) referred to as "petite generalizations."

There are multiple avenues for conducting DBR, and it would be impossible to delineate a list of prescriptive steps that all researchers should use regardless of design, theory, or context. However, based on the general principles presented in this chapter, practical steps include:

1) **Make explicit the assumptions and theoretical bases that underlie the work.** At times, this has meant defining assumptions and theory before the design work; at other times, these have evolved out of the work. However, as theoretical claims become apparent, research teams should discuss them as a group and write them down on paper – even if they are only naive conjectures.

2) **Collect multiple types of theoretically relevant data.** This typically involves field observations, log file data, interviews, questionnaires, and document analysis. An important component of this data should be that it is theoretically relevant, helping to inform evolving theories.
3) **Conduct ongoing data analyses in relation to theory.** I suggest weekly meetings among team members, again positioning the data to support or refute theoretical conjectures, and also determining how to systematically change the design in theoretically informative ways. Here is where the team engages in the process of building storied truths.

4) **Acknowledge the inseparability of the design and implementation.** It is quite common to treat a design as a fixed object, and in contrast I have argued that we need to consider that our designs are services to be optimized within and in response to the ecosystems within which they are expected to work. Treating ecosystem integration as a part of the design process results in more powerful outcomes.

5) **Distinguish between outcomes and outputs.** Many designs focus on optimizing the design and implementation process to achieve desired outputs (generally, student scores on standardized tests), as opposed to longer-term outcomes. It can be beneficial to consider the unintended consequences of various optimizations, and whether outputs are being obtained at the expense of outcomes.

6) **Illuminate the hidden curriculum and accompanying agendas.** All too often we consider education and our designed curriculum to be apolitical. In contrast, I argue that we should deconstruct the hidden assumptions that are bound up in the design decisions, underlying theories, and research interpretations. Taking the time to reflect on one’s assumptions can often illuminate biases we had not realized were affecting our work.

7) **Invite multiple voices to critique theory and design.** In many projects, this involves inviting teachers, students, and even external consultants to critique the design and resultant theoretical conjectures. These diverse groups provide different and much needed feedback.

8) **Have multiple accountability structures.** These structures include informal moments like when a student or teacher suggests they do not like a particular design aspect. At other times this might involve more formal meetings with local stakeholders to critique the project, or involve presenting the work at conferences or submitting articles and receiving feedback.

9) **Engage in dialectic among theory, design, and extant literature.** Participate in conferences and attend related talks, as well as talk with colleagues and stay current on both the academic literature as well as other related developments in commercial ventures.

The learning sciences studies learning within its full contextual splendor. This is why our work has the potential to truly change practice; but at the same time, it potentially undermines the generalizability of our claims. It is our responsibility as an emerging community to ensure that we conduct our research, and that we prepare the upcoming generation of learning scientists to conduct their research, in a manner that is methodologically rigorous and that results in theoretically useful claims that others consider informative, considerative, and new settings.

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informative, convincing, and useful – storied truths. Storied truths emerge over time, growing through a set of smaller research studies and societal happenings. However, over time, they can grow into a big theory, one that gathers momentum because of the work it does in the world and work the world does on reinforcing the theory. Importantly, we should acknowledge that each further node in the network that constitutes the emerging storied truth serves as an important translation, refining the theory and at the same time growing its value, even if what is learned are features of situations in which the theory has no application. The finicky nature of human beings and the contextualized nature of knowing and participation mean that each story has its own details, some of which change the underlying message and some of which serve to reinforce the core message. It is for this reason that a storied truth representing one population might look very different for another and even pass through meaningful translations and require additional frame factors to be relevant to a novel setting.

The best learning sciences research will advance storied truths that withstand translations, persisting even in the context of new actors, new authors, and new settings. The storied truths that can be retold and reapplied in a range of settings are more likely to be paradigm changing, and they are necessary to engineer change. Change will not occur simply through offering richer qualitative accounts, nor simply through employing quantitative methodologies. We need to convince policy makers and our colleagues that conducting good science involves more than employing experimental methods, but also involves demonstrating and evolving theory-in-context. Conducting good science involves using theory to inform real-world practice (through design) at the same time that this practice comes to inform theory – the essence of design-based research. Context, rather than something to be stripped away so as to produce some decontextualized yet ostensibly more generalizable theory, becomes interwoven with the theory in ways that allow others to see the relevance of the theory-in-context with respect to their local situation. Doing this in a manner that convinces others of the value of our work is a core challenge that design-based researchers must engage, especially if we want learning sciences to be a consequential form of social science.

References


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Microgenetic methods are concerned with reasoning, and prior to the learning processes, the learning of methods has not been necessary. Prior to the learning of methods, the learning and development of a set of beliefs and methods so that these beliefs have dictated which methods were to be used in this chapter by stating for the selection of methods.

However, the learning of a set of beliefs and methods is not a single, unitary process. Instead, it occurs by thinking. Further, it occurs by a long period of time. First, in the learning, a rare and dramatic performance. Third, learning is not a single, unitary performance. Instead, the learning process is a process of learning, learning, and learning, which include the independent component, which include the independent component.