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This article describes elements of an approach to research and development called *design-based implementation research*. The approach represents an expansion of design research, which typically focuses on classrooms, to include development and testing of innovations that foster alignment and coordination of supports for improving teaching and learning. As in policy research, implementation is a key focus of theoretical development and analysis. What distinguishes this approach from both traditional design research and policy research is the presence of 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.

Keywords: educational reform; learning processes/strategies; mixed methods; organization theory/change

An enduring goal of research in education has been to identify programs that can reliably work in a wide variety of settings so that such programs can be scaled up to improve system-level outcomes. But the observed treatment effects of nearly all programs vary significantly from setting to setting, and even the most promising programs have proved difficult to scale up. Improving educational systems, moreover, requires more than the adoption of effective programs; it demands alignment and coordination of the actions of people, teams, and organizational units within a complex institutional ecology (Rowan, 2002).

For decades, policy researchers have observed that strategies for producing alignment and coordination only from the top down rarely work (e.g., Cohen, Moffitt, & Goldin, 2007; Elmore, 1980; Rowan, 2002). Berman and McLaughlin (1975) observed that teachers' adaptations of programs at the classroom level, not policy makers' plans, largely determine programs' effectiveness. Implementation problems evolve, moreover, as programs go to scale, as a consequence both of the adaptations teachers make and of changes and variations in environments (McLaughlin, 1987). Successful scaling, most policy researchers agree, depends on local actors—especially district administrators, school leaders, and teachers—who need to make continual, coherent adjustments to programs as they work their way through educational systems (Weinbaum & Supovitz, 2010).

In this article, we argue for the potential of an emerging form of *design research* as a strategy for supporting the productive adaptation of programs as they go to scale. Because design research is an iterative approach to developing innovations, it is particularly well suited to informing decision making about needed adjustments to programs (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). The potential utility of design research for supporting implementation also derives from its focus on developing practical theory and tools that can be used to support local innovation and to solve practical problems (Reinking & Bradley, 2008). Further, the collaborative nature of much design research positions practitioners as codesigners of solutions to problems, which can facilitate the development of usable tools that educators are willing to adopt (Penuel, Roschelle, & Shechtman, 2007). Our perspective in this article has benefited from recent policy research that makes a turn toward design and makes use of theories of implementation to develop and study implementation supports for leadership practices (Honig, 2008; Spillane, 2006), instructional coaching (Gallucci, Van Lare, Yoon, & Boatright, 2010), and the coordination of school-linked services to improve student outcomes (McLaughlin & O'Brien-Strain, 2008).

Efforts by a number of interdisciplinary teams over the past decade to conduct design research at the level of educational systems have shown the significant promise of the strategy of engaging learning scientists, policy researchers, and practitioners in a model of collaborative, iterative, and systematic research and development. This represents a significant expansion of design research, which typically focuses on classrooms, to include development and testing of innovations that foster alignment and coordination of supports for improving what takes place in classrooms. We call this approach to collaborative research and development *design-based implementation research*, because design thinking figures prominently in it—as illustrated by the projects and initiatives we describe in this article—and because research on the implementation of reforms drives iterative improvements

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to designs. Researchers involved in these projects span multiple disciplines, including the learning sciences (where design-based research methods are common) and policy research (where policy and program implementation are often foci of theoretical development and analysis).

In this article, we elaborate on some elements that define design-based implementation research as it has been practiced, illuminating these elements by describing partnerships that exemplify each element and analyzing how the elements contributed to the partnerships' success. Next, we consider challenges to the approach and propose ways to organize a community of scholars whose aim is to develop, test, and improve this model of design research. Finally, we suggest ways to leverage existing federal investments to cultivate norms to guide and improve this model of research and development.

Elements of Design-Based Implementation Research

Since the 1990s, several interdisciplinary research and development teams have worked collaboratively with practitioners to develop and test designs for improving teaching and learning. These projects share four common elements:

- a focus on persistent problems of practice from multiple stakeholders' perspectives;
- a commitment to iterative, collaborative design;
- a concern with developing theory related to both classroom learning and implementation through systematic inquiry; and
- a concern with developing capacity for sustaining change in systems.

Below, we elaborate on these elements, presenting projects that exemplify each. Although all of the projects we describe employed all four elements, we highlight particular elements with individual cases that we judged to be especially indicative of those elements' potential.

Teams form around a focus on persistent problems of practice from multiple stakeholders' perspectives.

Design-based implementation research, as a descendent of the pragmatic tradition in American educational philosophy (e.g., Dillon, O'Brien, & Heilman, 2000), shares a commitment with other forms of design research (e.g., formative experiments, design experimentation) to using research to solve practical problems. What distinguishes it from most forms of design research, however, is how "practice centered" the problem definitions are. The SERP Institute, an organization that supports coordinated design research in large districts, exemplifies this approach (Donovan, 2011). The institute holds fast to the principles that (a) research and development should be a collaborative endeavor between researchers and practitioners, (b) partnerships should be based on addressing important problems of practice, and (c) practitioners should have a say in defining those problems. Many whole-school reform models, such as Success for All, already require teachers to have a say in adopting the programs in order to build ownership in the reform process (Datnow & Castellano, 2000). SERP goes further, requiring researchers to take up what educators perceive as local obstacles to improving teaching and learning. Initially, it is unlikely that teachers and leaders of schools and districts will share a definition of these obstacles, and their formulations are likely to differ widely from those of researchers. Thus a key early task in forming a partnership between researchers and an educational system is to develop a shared understanding of the problem or problems that will be taken up among people representing different stakeholder groups.

A core group of researchers and district and school leaders in a SERP site is tasked with defining an immediate problem of practice and agreeing on a plan of action for instructional improvement. In Boston, one of the four SERP sites established thus far, the core group initially collaborated around a middle school literacy challenge: improving students' knowledge of specialized academic vocabulary. To identify strategies for improvement, the core group chartered a design team with expertise on instructional materials, pedagogy, assessments, and data management and use by school staff, all focused on the selected problem. The design team drew on the expertise of two researchers, Catherine Snow and Richard Elmore: Snow to develop an intervention, Word Generation, to implement in schools, and Elmore to analyze the coherence of the instructional program at implementing schools. Snow and her colleagues conducted research on the impact of Word Generation on student learning (Snow, Lawrence, & White, 2009), and Elmore's research contributed to understanding the conditions under which its implementation was effective in improving student outcomes (Elmore & Forman, 2010).

In reflecting on what made the Word Generation experience successful, SERP researchers credit listening to and responding to educators' needs (Snow, 2011). By focusing on academic vocabulary—a persistent problem of practice that was affecting performance on accountability tests (a system-level outcome)—and by adhering to teachers' constraints on how much time they could allocate for the intervention, SERP researchers solidified the commitment of district leaders to the collaboration and built trust and buy-in among teachers (Donovan, 2010). In addition, bringing together learning researchers with policy researchers enabled the research on Word Generation to provide insight both into whether the program worked and into the conditions for success. That focus provided the district with the feedback it needed to justify further investment in implementation, as well as clues as to where to intervene to improve outcomes in future years.

To improve practice, teams commit to iterative, collaborative design.

Collaborative design research often focuses on the development and testing of usable tools for improving teaching and learning in specific subject matter domains and settings. A hallmark of design-based research in the learning sciences has been its focus on improving the learning environments of classrooms; however, learning scientists have, for the most part, had limited success in bringing their classroom innovations to scale at the level of educational systems (Pea & Collins, 2008). As a consequence, some learning scientists have begun to focus more explicit attention on designing learning opportunities for teachers. For example, some researchers have helped teachers learn to enact inquiry-oriented curricula by designing educative curriculum materials for them

(e.g., Davis & Krajcik, 2005); some have designed professional development programs to better equip school and district leaders for supporting classroom-based reform (e.g., Bowyer, Gerard, & Marx, 2008). Some learning scientists have collaborated with policy researchers, who engage theories of organizational and institutional change in designing new approaches for bringing about systemic improvements (e.g., Bryk, Gomez, & Grunow, in press; Resnick & Spillane, 2006).

A good example of a design-focused multiyear collaborative research and development effort is the Middle School Mathematics and the Institutional Setting of Teaching (MIST) project at Vanderbilt University (Cobb, Henrick, & Munter, 2011). MIST is a five-year project in which a team of learning scientists, policy researchers, and educational anthropologists work in collaboration with four school districts to analyze and inform policies for improvement in mathematics instruction as part of a participatory, collaborative approach to research. In a departure from traditional design-based research where researchers establish the learning goals, in MIST the district makes decisions and drives the designs for helping improve how teachers enact ambitious instructional practices in mathematics. The research team helps facilitate the design process, first by eliciting a policy-based theory of action from different actors in the system and then by conducting research on the implementation, informing future cycles of design and implementation.

Like many large urban districts with high levels of socioeconomic and cultural diversity, "District B," a MIST partner for four years, is under pressure to improve student outcomes in mathematics to satisfy the mandates of No Child Left Behind. Its theory of action is to improve the quality of instruction by creating new positions (coaches in mathematics to provide instructional supports to teachers) and implementing new routines to support principals' instructional leadership in mathematics (e.g., learning walks, or "walkthroughs," co-led with coaches, whereby the principals observe mathematics instruction in their schools). The MIST research team conjectured that the coaches' subject matter expertise and new roles could plausibly lead to achieving the district's goal, but the team expressed concern that the principals lacked sufficient expertise in mathematics to make effective use of the learning walks and that the learning events organized for principals were too isolated to make up for their lack of expertise. Over the first year of data collection, the team discovered that principals were not in agreement about the policy goal. Many saw their job as requiring a sharper focus on instructional management (ensuring compliance to teaching to standards) rather than on the instructional improvement goals established by district leaders.

What happened next makes MIST a good example of how design-based implementation research can contribute to system improvement. The Vanderbilt team shared their conjectures and research findings with district leaders at the end of the year in a highly facilitated meeting that left plenty of time for discussion. Researchers were able to make evidence-based recommendations to district leaders about the importance of making the vision more explicit for all principals and increasing the coherence of principals' learning supports in the context of their district. These recommendations were partly reflected in the revised theory of action that the district implemented the next school year to support instructional improvement. The district's leadership focused on making sure that supervisors of principals had expectations consistent with the district's theory of action; the leadership also placed increased emphasis on how to communicate those expectations to principals. The Vanderbilt team also organized more sustained professional development for principals. Although the team did not see all of its recommendations fully implemented, its presentation and collaborative approach paid off in terms of influence on policy at the district level.

As a strategy for promoting quality in the research and development process, teams develop theory related to both classroom learning and implementation through systematic inquiry.

In its focus on the persistent problems of practice and the collaborative approach, design-based implementation research shares some features of participatory approaches to educational evaluation (see especially Fetterman, 2001). Also, like rigorous, well-designed program evaluation studies, the research is informed by theories of how people learn in particular contexts (e.g., Donaldson, 2007). However, in contrast to most evaluation studies—which are motivated by practical and policy questions—design-based implementation research aims to develop and refine theory through systematic inquiry (Cobb et al., 2011). The objects of this theory development include explicit ideas about how to support classroom learning, about how to prepare teachers and administrators to implement programs, and about how to coordinate the implementation of programs within and across organizations (Confrey, Castro-Filho, & Wilhelm, 2000). Design-based implementation research can also contribute to theories of organizations and institutions that guide much contemporary policy research in education, particularly by pointing out how the deployment of new tools (e.g., curricula, technologies) can bring to light new needs for coordination across different system levels and for capacity building (e.g., Stein & Coburn, 2008). In design research, it is through the analysis of what happens when researchers engage in design and help support implementation that theory develops (Edelson, 2002).

At the Center for Learning Technologies in Urban Schools (LeTUS), a research center funded by the National Science Foundation, a key focus was to develop a theory of the conditions under which a technology-supported innovation in science could be *usable* to a wide range of teachers (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000). Usability is a concept that describes an ideal of software design, and the LeTUS team sought to explore its applicability to education. Immediately, and as a direct consequence of the team's efforts to deploy technology in the Detroit Public Schools and the Chicago Public Schools (which were partners in the Center), the team saw that the value of technology lay not in what it could do on its own but in its integration with successful curriculum materials. In addition, LeTUS researchers confronted the different layers of the system that affected student access to computers and realized that actors in different departments and schools would need to coordinate their activities to implement technology successfully in the classroom. In urban schools, if technology is to be usable, there must be a "fit" of the innovation to school culture, technical capability, and policies (Blumenfeld et al., 2000). If the gap between the

capacity of a system and the requirements of an innovation along any of those three dimensions is large, a technology-supported innovation will be less usable. Where gaps are large, designers have a choice to scale down the demands along one or more dimensions or to intervene to enhance system capacity, improving chances that an innovation will be usable.

The LeTUS example illustrates what can be learned about policy and program implementation from engaging in the activity of design. By having to plan for implementation in classrooms and then adapt the plans on the basis of what the team discovered through its research activities, the team refined its definition of the problem at hand, shifting from the idea of usability as a relationship between a technology capability and the task at hand (the definition from software design) to the idea of usability as entailing the capability of systems to make good uses of technology. This shift led to theory building about the systemwide conditions of scalability and sustainability up front in design, a primary goal of design-based implementation research.

Design-based implementation research is concerned with developing capacity for sustaining change in systems.

One strategy for promoting the sustainability of designs is to develop capacity through intentional efforts to develop organizational routines and processes that help innovations travel through a system. The LeTUS team was not the first to claim or discover that the capacity of systems acts as both a resource and a constraint for change: This idea has been fundamental in policy analyses for some time (e.g., Darling-Hammond, 1993). However, the predominant approaches to building capacity in education have long been focused on improving human capital—whether through professional development or by selecting and rewarding teachers on the basis of their students' test scores—and on developing and supplying improved material capital (e.g., curriculum). Often overlooked as a potential target for design efforts is improving social capital, that is, the resources and expertise that individuals can access to accomplish purposive action. A teacher's colleagues, for example, can be an important resource for implementing new reforms (Frank, Zhao, & Borman, 2004). Routines in schools, such as those that teachers use to structure conversations about teaching and learning in teams, serve as important resources for teachers' own learning and growth (Horn & Little, 2010). School administrators' processes for coordinating reform activities likewise can be resources for leading change efforts (Spillane, 2006). Design-based implementation research can help develop local capacity by fostering cohesion among networks of local actors tasked with implementing change, and by creating designs for routines and coordination mechanisms that can help innovations travel readily along those networks and that themselves can travel to new contexts.

A good example of a research and development effort focused on creating routines for innovation and coordination that travel well is the Fifth Dimension, part of the UC Links program in the University of California system (Cole & Distributed Literacy Consortium, 2006). Developed initially by Michael Cole and colleagues at the Laboratory for Comparative Human Cognition at the University of California, San Diego, the Fifth Dimension links university students and faculty to local communities through the joint activity of planning and running an after-school program. For children, participation is voluntary. For the undergraduates who help staff and research the program, attendance is part of a for-credit class. Program activities include academic, school-like tasks, but they are assigned within a broader context of learning through play.

The Fifth Dimension program is a good example of capacity building because its routines and organizational processes have traveled well to support the formation of more than three dozen university–community partnerships nationally and because it has proved successful in promoting a range of traditional academic and other types of outcomes. The necessary student labor is counted in the cost of running a course for the university, making the program attractive to communities and sustainable as a program that offers something to children in community settings and that helps undergraduates learn about human development. Designing for sustainable improvements in teaching and learning is the ultimate goal of design-based research, and as part of that, identifying and putting into place routines and processes that build or leverage existing capacity to support programmatic scalability is a crucial step.

Furthermore, the program's developers consider the adaptation required when implementing the program in a new site as a core object of research study. Notably, the primary interest of Cole and his colleagues in studying the Fifth Dimension has been in "tracing implementations in widely disparate conditions" to better understand the conditions under which the design principles are appropriated and transformed as the program is integrated with the values, norms, and practices of host institutions (Cole & Engeström, 2006, p. 500). These findings help the team to refine theories of how the sociocultural setting shapes adoption of particular program elements.

Threats and Challenges to the Success of Design-Based Implementation Research

There are significant practical challenges to engaging in design-based implementation research (Donovan, Wigdor, & Snow, 2003). The demand of the public and of schools for quick success from reforms often makes researchers uneasy. On their own, researchers may not have the capacity to function successfully as reform intermediaries at the same time that they are conducting research; effective partnerships are likely to require an intermediary organization whose primary focus is capacity building, not research. In addition, much policy discourse on—and funding of—large-scale research on innovations leans toward the need to promote implementation fidelity rather than toward productive, mutual adaptation of programs. Funding cycles of both federal agencies and private foundations typically are short, and ongoing funding of collaborations for the time required for building capacity is rare, making the multidisciplinary projects that serve as examples in this article the exception rather than the norm for organizing research and development efforts.

Just as design-based researchers often seek out classrooms that are suitable contexts for innovations (e.g., Reinking & Bradley, 2008), the teams discussed above have worked largely within education systems that were "ready for change." In other words, the researchers have focused their efforts on places where they shared a broad vision for improvement with district officials. This may be a necessary condition for partnerships, and even in the above

examples where that condition is met, coordinating change has often proved a greater challenge than the research and development teams are equipped to solve. An ongoing challenge, which we hope can begin to be addressed in future projects, is the development of theories and models that can be used to initiate change where capacity is more limited and to develop designs for coordination that are better tailored to different contexts, including those that convene different kinds institutional and individual actors in and out of school to study and bring about improvements to children's learning. An example is the Youth Data Archive (McLaughlin & O'Brien-Strain, 2008), where researchers facilitate the assembly of data sets across different kinds of organizations (e.g., schools, social service agencies). Researchers involved with the Youth Data Archive help collaborative groups that provide the data to pose questions of these data and use the answers to inform the design of strategies to improve and coordinate services for youth. In addition, teams conducting design-based implementation research will need to identify ways to involve young people themselves in designing and studying the educational systems of which they are part, both as a way to expand collaborations and as a strategy for promoting youth development (Kirshner, O'Donoghue, & McLaughlin, 2005).

Finally, an enduring challenge of design-based implementation research is to coordinate the activities of research and development. The projects described above involved multiple teams whose work had to be coordinated. In many instances, the practical work could have easily overshadowed the need for rigorous research. It was only because the research teams were diverse, with specialized roles for their members, that they were able to conduct the kinds of experimental, quasi-experimental, and mixed-methods longitudinal studies that they did. Even so, in their accounts of the design process, researchers did not always detail alternative approaches to redesigning innovations, explain how empirical evidence informed changes, or describe alternative approaches to design and evidence that might have supported those approaches. These challenges suggest an important role for research on the *processes* of research and development, to make visible the tensions and challenges in the work, as do the case studies in a recent edited volume on bridging the research–practice divide (Coburn & Stein, 2010).

Looking to the Future: Organizing for the Improvement of Design-Based Implementation Research

A first step toward developing design-based implementation research as a systematic form of inquiry and practice is to establish shared norms and practices regarding theory development and the specification and testing of specific claims or conjectures. In other words, the approach needs to establish a distinctive "argumentative grammar" (Kelly, 2004) for judging the adequacy of data supports for particular claims and theories and for warrants that link claims to data. In design-based implementation research, the driving question may sometimes be one of "what works," in which case experimental designs may be appropriate. Instead, much design-based implementation research asks questions such as "What works when, how, and for whom?" "How do we improve this reform strategy to make it more sustainable?" and "What capacities does the system need to continue to improve?" Answering these questions and the many subquestions needed to develop and validate theory-based innovations will require a wide range of research methods. Longitudinal, historical, ethnographic, and case analyses of changing contexts are likely to be necessary to understand how reforms' trajectories across time and settings shape implementation.

A second activity around which a community of scholars might organize is to develop standards regarding the use of evidence to guide refinements to design. If research and researchers are to mediate improvements, the community must articulate norms and practices regarding how to incorporate multiple points of view on problems and conflicting interpretations of data. One approach could be to encourage the use of *design rationales,* that is, accounts of the decisions teams make and the reasons for their decisions (Moran & Carroll, 1996). Professionals in the fields of architecture, urban planning, and software engineering articulate design rationales to clarify the purposes of designs, record the history of the design process, and reflect on and modify designs. In design-based implementation research in education, design rationales might serve as a means to make visible (and public for external review) the ways that teams employ evidence to resolve conflicts, weigh competing approaches to improvement, and identify new areas of focus for their work.

Finally, to develop a community, scholars will need resources for conducting their work and venues for communicating their findings. Already, the National Science Foundation encourages scholars to propose implementation research studies for its Research and Evaluation on Education in Science and Engineering Program competition. But at the Institute of Education Sciences, design-based implementation research would currently need to take place in the context of intervention development. One way for both the institute and the National Science Foundation to support design-based implementation research would be for requests for proposals to give priority to existing research–practice partnerships that have been successful, so that partnerships can develop new projects from groups with a shared history of collaboration. Finally, this area of research needs new publication outlets that appreciate the interdisciplinary, iterative nature of the research. Many design-based implementation research studies are "fugitive documents"; that is, they appear as book chapters, online reports, or manuscripts. Peer-reviewed journals that publish articles at the intersection of policy and learning sciences in particular are needed, where the work is currently most concentrated.

We are optimistic about the potential of design-based implementation research and believe that resources for it can be identified, because this kind of research directly addresses important and timely policy concerns, namely, scaling up and sustaining change, and because it builds on prior work in both policy and learning sciences. The examples presented in this article illustrate how collaborative design that focuses on problems of practice can produce effective programs, help school districts augment the supports they provide to teachers for improving their instruction, contribute to advances in theory about what makes an innovation usable, and develop system capacity. The task ahead is to enable a broader community to undertake design-based implementation research systematically. Doing so will involve expanding the model to address present and emerging challenges so that it can have significant impact on the field of education.

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