Theories and Research Methodologies for Design-Based Implementation Research: Examples From Four Cases

JENNIFER LIN RUSSELL*

University of Pittsburgh

KARA JACKSON*

University of Washington, Seattle

ANDREW E. KRUMM

SRI International

KENNETH A. FRANK

Michigan State University

*co–lead authors

This chapter reviews four projects that reflect the principles of design-based implementation research (DBIR) in an effort to highlight a range of relevant theoretical and methodological perspectives and tools that can inform future work associated with DBIR.

The goal of this chapter is to highlight a range of relevant theoretical and methodological perspectives and tools that can inform future work associated with design-based implementation research (DBIR). As Penuel, Fishman, Cheng, and Sabelli (2011) described, DBIR entails engaging "learning scientists, policy researchers, and practitioners in a

National Society for the Study of Education, Volume 112, Issue 2, pp. 157-191

model of collaborative, iterative, and systematic research and development" designed to address persistent problems of teaching and learning (p. 331). Addressing persistent problems of teaching and learning requires attending not only to theories of learning but also to theories of implementation and organizational context. Furthermore, conceptualizations of learning, implementation, and organizational context have implications for the design of interventions and the methodologies used to answer questions like: "What works when, how, and for whom? How do we improve this reform strategy to make it more sustainable? What capacities does the system need to continue to improve?" (Penuel et al., 2011, p. 335).

To organize our discussion of theories and methods relevant to DBIR, we have selected four projects that exemplify its core principles. For each, we examine how theories and methods are central to conceptualizing and carrying out projects that reflect the principles of DBIR, and we pose the following questions:

1. How does the project conceptualize and/or attend to the learning of various actors? What role do theories of learning play in the project's design of interventions and plans for implementation?
2. How does the project conceptualize and/or attend to implementation and the role of organizational contexts? What role do theories of implementation and organizational contexts play in the project's design of interventions and plans for implementation?
3. What approaches have projects taken, methodologically, to answer their driving questions? How are methodological decisions connected to particular theories of learning, implementation, and/or organizational contexts?

Our goal is to highlight approaches to using and generating theories and methods in ways that we view as well suited to advancing DBIR. These perspectives and approaches represent useful starting places for researchers and practitioners engaged in the early stages of work that exemplify the principles of DBIR. The highlighted theories and methods are meant to be illustrative rather than exhaustive, and as researchers and practitioners continue to engage in projects that employ a DBIR approach, we expect that teams will expand the list of relevant theories and methods for DBIR. Finally, although we have organized the chapter around the DBIR principles, we do not mean to suggest that particular theoretical perspectives or methodologies are only appropriate to particular principles.

Our discussion of each case is structured as follows: First, we provide a short overview of each project. Then we examine the way theories of

learning, implementation, and/or organizational context inform the project. We also examine how theoretical orientations motivate the choice of particular methodologies. Looking across cases, we aim to illustrate how multiple theories and methods that take into account interactions at different levels of educational systems (e.g., classroom, school, district) are necessary to design, investigate, and improve particular interventions, if persistent problems of teaching and learning are to be addressed. Additionally, each case illustrates how the project's core purpose drives the selection of theories and methods.

CASE 1: THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING'S PATHWAYS™

The first guiding principle of DBIR is its "focus on persistent problems of practice from multiple stakeholders' perspectives" (Penuel et al., 2011, p. 332). We selected the Carnegie Foundation's Pathways™ program (see Dolle, Gomez, Russell & Bryk, 2013, this Yearbook) as an example of a project that has used a range of strategies to ensure that participating practitioners, designers, and researchers jointly negotiate and articulate the problem of practice that provides a focus for collaborative improvement work.

The Pathways programs were motivated by the rising proportion of community college students who are placed in remedial mathematics courses to build basic skills but subsequently fail to complete the necessary courses to earn college credit and graduate (Bailey, Jeong, & Cho, 2010; Boatman & Long, 2010; Calcagno & Long, 2008). Recognizing the "grave consequences for individual opportunity and more generally for our economy and society" (Carnegie Foundation, 2012a), Carnegie organized faculty members, researchers, designers, and improvement specialists in a Networked Improvement Community (Bryk, Gomez, & Grunow, 2011; Engelbart, 2003) to engage in the creation and ongoing improvement of two new mathematics pathways: one in statistics (Statway™) and the other in quantitative literacy (Quantway™). The Pathways aim to take students to and through college mathematics within one year, replacing a sequence of courses that can take as long as 2 years. Carnegie coordinated the development of curricula, online out-of-class activities, and assessments that form the core of the Pathways instructional program.

EMPLOYING THEORY TO GUIDE ORGANIZING FOR IMPROVEMENT

As in other educational research, the Pathways work is grounded in relevant theories of learning. For example, design of the instructional system was influenced in part by theories of mathematics learning

that emphasize student engagement in productive struggle (Hiebert & Grouws, 2007) with high-level tasks (Hiebert & Wearne, 1993; Lampert, 2001; Stein, Grover, & Henningsen, 1996; Stein & Lane, 1996). In addition, the Pathways program sought to attend to a growing body of psychological theory pointing to the role of noncognitive factors in shaping student success, such as academic behaviors, perseverance, mindsets, learning strategies, and social skills (Duckworth, Peterson, Matthews, & Kelly, 2007; Dweck, Walton, & Cohen, 2011; Farrington et al., 2012; Heckman & Kautz, 2012; Tough, 2012). Carnegie sought to better conceptualize and intervene in these noncognitive factors through their work to build students' productive persistence, defined as "tenacity plus effective strategies." Productive persistence is a theory of psychological strategies that improve student motivation, engagement, and achievement, specifically in the context of developmental courses in community colleges (Yeager, 2012b).

The development of a theoretically grounded instructional system is just one part of a broader effort to use the tools and routines of improvement science research (Berwick, 2008; Gawande, 2009; Langley et al., 2009) to engage a distributed network of colleagues to learn from efforts to improve mathematics teaching and learning. By seeding the formation of two Networked Improvement Communities (NICs)[1], Carnegie aimed to build an infrastructure that enables practitioners, researchers, and designers to work together to specify a problem space, develop and test new tools and practices to address the problem, and analyze data to set improvement goals and targets. Organizing a diverse network of colleagues distributed across institutions and geographical areas generates both organizational opportunities and challenges. As social capital theory suggests, networks enable participants to access valued resources, such as new pools of expertise, through their connections in a network (Adler & Kwon, 2002; Lin, 2001). In the case of the NIC, these resources include expertise in mathematics teaching and learning, student motivation, improvement science methodologies, and reform implementation, to name just a few. NIC activities that bring researchers, designers, and practitioners together in joint improvement work help to ensure that the knowledge of practice, research, and theory is brought to bear in the generation of solutions to problems of practice (Coburn & Stein, 2010).

Routines grounded in improvement science research form the core technology of the NIC (Berwick, 2008; Gawande, 2007; Langley et al., 2009). Using an approach adapted from the Institute for Healthcare Improvement (IHI), Carnegie is building an infrastructure for scanning and synthesizing what we know from scholarship and practice, rapidly developing and testing prospective interventions to drive improvement, and learning what works when interventions are implemented (Carnegie

Foundation, 2012b). Although the primary goal of traditional research is contribution to the field's broader knowledge, inquiry in the context of the Pathways work is principally aimed at contributing to the ongoing implementation and improvement of interventions. By linking networks of practitioners and researchers in joint improvement work, the field can, in theory, accelerate improvement by spreading change ideas within and between organizations (Massoud et al., 2006; Nolan, Schall, Erb, & Nolan, 2005).

Coordinating work that spans organizational boundaries and engages professionals with different backgrounds, orientations, and worldviews is no small task (Provan & Milward, 1995). Organizational routines are a promising means to coordinate the distributed work of a network and promote the use of improvement science methodologies. Feldman and Pentland (2003) defined routines as "repetitive, recognizable patterns of interdependent actions, carried out by multiple actors" (p. 94). Organizational theory refers to routines as "effortful accomplishments," not mindless activity (Pentland & Reuter, 1994, p. 488). Routines are one of the ways organizations get work done, because they provide a coordination mechanism (Cyert & March, 1963; March & Simon, 1958; R. R. Nelson & Winter, 1982) and help to stabilize practice (Coombs & Metcalfe, 2000; Hodgson, 1993; Langlois, 1992; R. R. Nelson, 1994). Although traditionally associated with stability, scholars have recently explored how organizational routines can be a vehicle for the diffusion of innovation (Sherer & Spillane, 2011; Spillane, 2012; Spillane, Gomez & Messler, 2009).

The Carnegie Pathways program employs a number of routines to coordinate improvement work in the NIC, including a modified lesson study routine, monthly conference calls organized by role groups (e.g., faculty, administrators), and a quarterly reporting cycle conducted by a team charged with developmental evaluation. Using routines from improvement science, Carnegie conducted a root-cause analysis to map the problem space and analyze the system that produces high failure rates in developmental mathematics courses in community colleges. Mapping the problem space resulted in a design and implementation strategy that addresses multiple components of the system (see Dolle et al., 2013, this Yearbook).

A significant benefit of organizational routines is their capacity to generate shared understandings among participants (Cohen & Bacdayan, 1994; Feldman & Rafaeli, 2002; Hutchins, 1995; Weick & Roberts, 1993). By fostering connections among individuals engaged in joint organizational tasks, routines help people develop shared understandings about what actions will be taken and how these actions relate to broader organizational goals (Feldman & Rafaeli, 2002). The Pathways NICs foster shared

understandings of the problems and solution space by including practitioners, researchers, and designers in routines to specify the problem space and design and test interventions. In addition, diverse participation improves the chances that subsequent designs and improvement work are built on the accumulated knowledge of both research and practice.

USING IMPROVEMENT SCIENCE METHODOLOGIES TO DESIGN, STUDY, AND IMPROVE LEARNING INTERVENTIONS

The Carnegie Pathways case also highlights the use of improvement science methodologies and tools to design, study, and improve the implementation of interventions. Here, we focus on how the project used improvement science routines to develop and refine interventions to address students' productive persistence in developmental mathematics courses. Specifically, we focus on the use of routines that guide participants to define and iteratively refine the problem and solution space necessary to make the Pathways program responsive to students' motivation and persistence.

For example, the work on addressing noncognitive factors in learning was launched with a routine developed by Proctor & Gamble and adapted by IHI: the 90-day cycle (Huston & Sakkab, 2006). It includes a scan of the field, distilling the knowledge of scholars and practitioners, the generation of practical theories to refine and test understandings about what works, and planning for the dissemination and use of the findings by relevant stakeholders.[2] A team consisting of expert practitioners, researchers, and improvement specialists engaged in a 90-day cycle focused on math student motivation and engagement that resulted in the identification of a list of the psychological factors that promote community college students' productive persistence in developmental mathematics and measures of those factors. At various points in the cycle, the team sought input from practitioners and the scholarly community to distill a set of factors that promote student success. Conclusions were disseminated in various network venues.

The conclusions from the 90-day cycle formed the basis for a framework to guide ongoing improvement work related to productive persistence, through the specification of a productive persistence "driver diagram" (see Dolle et al., 2013, this Yearbook, for more details). The driver diagram, a tool adapted from improvement science research, helps to conceptualize an issue and its system components and articulate a causal pathway to achieve a desired outcome (Bryk et al., 2011; Langley et al., 2009). Informed by the driver diagram, designers infused the curriculum with activities that target students' mindsets and develop their learning strategies. Interventions typically require minimal class time and are

grounded in psychological research that has demonstrated lasting effects of microinterventions (Yeager & Walton, 2011). Together, the tools and routines provide a mechanism for coordinating distributed work such as the design of interventions and attempts to implement them in varying local contexts.

By developing common tools (e.g., driver diagrams and curriculum materials) that are generated and refined through routines, the Pathways program attempts to promote "implementation with integrity," which means that instructional materials and practices are adapted to local contexts but maintain agreement with the core design principles and the theory of change explicated in the driver diagrams. By stabilizing practice so that the community adheres to core design principles, the resulting variability in implementation and outcomes can be subjected to disciplined inquiry and ultimately guide the refinement of materials and practices. By providing a degree of stability, tools and routines provide a contrast required to detect novelty (Becker, 2004). Stability provides a baseline against which to assess variation, make comparisons, and ultimately learn (Becker, 2004; Langlois, 1992; Knudsen, 2002; Tyre & Orlikowski, 1996).

Common tools, like the driver diagram, support the measurement work that is necessary to learn from implementation, local improvement work, and resulting variation in outcomes. A key tenet of improvement science research specifies that in order to improve something, we must also be able to measure it (Bryk, 2009; Gawande, 2007). Common measures enable a community to know whether changes in practice actually constitute improvements (Bryk et al., 2011; Langley et al., 2009). Drawing on traditional survey design methodology, a team composed of expert practitioners and researchers developed a set of measures of the drivers of productive persistence. They first identified approximately 900 potential survey measures of the constructs represented in the driver diagram. These items were reduced to 26 items that take roughly 3 minutes to answer. After initial piloting, the measures were embedded in the Pathways online instructional platforms, and students were directed to complete items periodically when they logged in to complete homework. This allowed the team to regularly assess progress toward the aim and the impact of microinterventions. When behavior is stabilized through tools and routines, measurement can assess the variation in implementation and its relationships to outcomes. Routine behavior is easier to monitor and measure than nonroutine behavior (Langlois, 1992), and the more standardized, the easier it is to compare (Becker, 2004).

Researchers conducted a validity study of the items with a national sample of college students. In preliminary analyses, the brief set of

productive persistence measures accounted for a substantial and meaningful amount of the variance in students' mathematics test scores, above and beyond common background characteristics such as race, ethnicity, income, and baseline test performance (Yeager, 2012a). Establishing the predictive validity of indicators of productive persistence is an important component of the NIC's improvement work because it helps to establish that productive persistence is a driver that contributes to improving student performance in mathematics courses. If the indicators of productive persistence did not predict student performance to a significant degree, given confidence that the measures are tapping into the underlying construct, then the community would need to revise the driver diagram and, ultimately, their strategy for improving developmental mathematics teaching and learning. In this way, measurement becomes an important component of an overall improvement strategy, and an important tool in DBIR research more broadly.

SUMMARY

The Carnegie Pathways work exemplifies the iterative dialogue between theory, design, implementation, and research that is inherent in good DBIR. Learning theories of productive struggle and psychological theories of motivation and engagement inspired design of classroom interventions and also motivated the development of a measurement system to track community progress toward a shared aim. Theories of organizational routines are put into practice in designs for scaling up change efforts, the ongoing study of implementation, and, notably, in the way that focal problems of practice get selected and understood.

CASE 2: THE JOHN W. GARDNER CENTER'S YOUTH DATA ARCHIVE

The second guiding principle of DBIR is a "commitment to iterative, collaborative design" (Penuel et al., 2011, p. 332). We turn to the John W. Gardner Center's Youth Data Archive as an example of a project that illustrates this principle. The YDA project aims to create an integrated longitudinal data system that combines administrative records from a variety of public and nonprofit institutions serving youth in the San Francisco Bay Area (McLaughlin & London, 2013, this Yearbook). This unique university–community collaboration enables practitioners and local policy makers to work across institutional boundaries and address complex social issues, such as youth development, that implicate multiple departments and organizations. In addition to providing an infrastructure for collecting and analyzing data, the YDA engages community partners in action-oriented research that can support improvements

to educational and other developmental programs and youth services. YDA teams comprising researchers and community partners engage in long-term collaborations in which they iteratively examine data to better understand problems facing youth and develop targeted plans for redirecting community efforts to support youth. In so doing, YDA aims to build the capacity of community agencies to use data and ask actionable questions that support the design and refinement of learning opportunities for youth.

One example of a YDA collaboration is San Francisco's Bridge to Success (BtS) initiative, which brings together the City and County of San Francisco, the San Francisco Unified School District (SFUSD), the City College of San Francisco (CCSF), and other community organizations and foundations to promote postsecondary success for underrepresented students. The goals of the partnership are to create shared ownership and responsibility for postsecondary attainment and to build a coordinated strategy for on-the-ground changes needed to make a real difference in the lives of youth (John W. Gardner Center, 2012). To help achieve these goals, YDA provides research and analytic support to assist BtS partners in making informed policy or programmatic changes. For example, YDA analysts worked with SFUSD staff to develop indicators for identifying students who are at risk for not graduating from high school (John W. Gardner Center, 2011). The YDA conducts ongoing analyses to identify the most predictive indicators of high school graduation for students in SFUSD. These analyses informed the District's design and refinement of a transitional summer program for students identified as at-risk for not graduating.

DRAWING ON LEARNING THEORIES THAT CONCEPTUALIZE YOUTH DEVELOPMENT AS A CROSS-SETTING PHENOMENON

McLaughlin and London (2013, this Yearbook) describe YDA's work as informed by a "societal sector framework," which emphasizes the need for cross-sector collaboration as a strategy for addressing complex social problems such as youth development. This perspective is relevant to the implementation of designs for learning because it calls attention to how complex processes such as education and youth development are constituted by the existence and interaction of a diverse range of organizational actors (DiMaggio & Powell, 1983; McLaughlin & Talbert, 2001; Rowan, 2002). It also calls attention to how the significant organizations engaged in work with youth—schools, informal learning organizations, hospitals and clinics, social service agencies, and juvenile justice—are well recognized and stable institutions but together form a fragmented and largely uncoordinated system (Scott, Deschenes, Hopkins, Newman & McLaughlin, 2006).

As a strategy for youth development, YDA's work to support collaboration among typically disconnected institutions is consistent with theories that conceptualize learning as a cross-setting phenomenon (e.g., Barron, 2006, 2010; Beach, 1999; Dreier, 2000; Jackson, 2011; Stevens, Satwicz, & McCarthy, 2008; Wortham, 2006). Studies such as these suggest that an individual's participation in any particular event is shaped not only by what happens in that event or setting over time but also by the individual's participation in events in other settings and how resources and relationships are linked between events and settings.

Conceptualizing participation and learning as a cross-setting phenomenon has implications for the design of interventions. It suggests the utility of designing for "brokers" and "boundary objects" (Wenger, 1998) to facilitate transitions between settings. A number of YDA projects seek to understand and design support for learner transitions across institutions, such as when learners move from school to out-of-school learning environments (Castrechini & Ardoin, 2011) or from high school to college (John W. Gardner Center, 2011). As Barron (2010) suggested, designing for productive transitions creates opportunities for youth's learning. And as youth make use of and develop resources to productively navigate settings, they develop social capital, which then positions them to engage in a wider variety of activities and thus enhance their skills, knowledge, and practices.

ORGANIZING CROSS-SECTOR COLLABORATION AROUND THE EFFECTIVE USE OF DATA

In fostering cross-sector collaboration, YDA's work facilitates the formation of new, networked forms of organization engaged in a collective effort to make progress on a common issue. For example, San Francisco's BtS seeks to connect key actors in a region that can help underrepresented youth attain a college education, including a school district, higher education institutions, community-based organizations, and foundations. In this respect, the BtS formed a network to foster connections among organizations that typically operate independently, even when addressing the same complex problem. As noted in the discussion of Carnegie's Pathways program earlier, networked forms of organization can foster a number of valued outcomes, such as the diffusion of information and expertise (Adler & Kwon, 2002) and the activation of collective responsibility or norms of engagement (Penuel, Frank, & Krause, 2010). These features of networks are particularly helpful when tackling complex social problems that are, by nature, cross-sector phenomena.

An emerging body of literature seeks to describe the conditions under which data sets such as those integrated through the YDA can be used to support improvement efforts in schools. Moving past the rhetoric of

"data-driven decision making," scholars highlight the constellation of supports necessary for effective data use (e.g., Coburn & Turner, 2012). For example, effective data use is often dependent on what data are collected and when (Means, Padilla, & Gallagher, 2010); the value individuals place on using data (Coburn & Talbert, 2006); the power relations associated with individuals collecting and using data (Colyvas, 2012); organizational culture (Firestone & Gonzalez, 2007); and individuals' facility and comfort in working with "numbers" (Means, Padilla, DeBarger, & Bakia, 2009). Framed in more general terms, effective data use is often dependent on how individuals make sense of data (i.e., how they interpret it and attach meaning to some data over others), because data are subject to multiple interpretations as they move throughout an organization or network of actors (Spillane, 2012).

One strategy that YDA uses to help shape interpretation of data toward productive outcomes is engaging with common partners throughout the life cycle of data, from their collection, analysis, and action-steps in collaboration with community partners. Moss (2012), citing Bowker and Star (1999), identified the following theoretical issues that are at play in efforts to follow and scaffold the life cycle of data:

> (1) How objects can inhabit multiple contexts at once, and have both local and shared meaning. (2) How people, who live in one community and draw their meanings from people and objects situated there, may communicate with those inhabiting another. (3) How relationships form between (1) and (2) above—how can we model the information ecology of people and things across multiple communities? (4) What range of solutions to these three questions is possible and what moral and political consequences attend each of them? (p. 293)

Theories of data use implicitly inform the ongoing approach that YDA analysts take in their work with community partners, including the need to actively engage stakeholders in analysis and interpretation and the need for scaffolded meaning making around the data (Little, 2012; T. H. Nelson, Slavit, & Deuel, 2012). We next discuss how YDA facilitates coordinated productive data use across sectors.

DESIGNING METHODOLOGIES TO SUPPORT PRODUCTIVE DATA USE ACROSS SECTORS

A significant contribution of YDA is the development of methodologies for supporting productive data use across actors and agencies that have typically operated independently of one another. As part of their methodological approach, the YDA team checks in with contributing

partners and others at key points, such as when data are first analyzed, when draft analyses are completed, and when partner feedback has been incorporated to generate interpretations (McLaughlin & London, 2013, this Yearbook). This process helps partners feel engaged in the process; therefore, they are more likely to have confidence in the data and view the data as a tool for action. In addition, by providing opportunities for sensemaking, YDA analysts facilitate the transition from information to actionable knowledge (McLaughlin & O'Brien-Strain, 2008). Sharing data across agencies, which involves making indicators of the efficacy of partnering agencies' work public, can make partners feel vulnerable and jeopardize burgeoning collaborative relationships (Weitzman, Silver, & Brazill, 2006). In forming long-term relationships, participants are more likely to develop the trust necessary to explore difficult questions. Long-term relationships also have the potential to generate opportunities for ongoing inquiry that are more likely to influence practice. For example, successive iteration of the questions asked by the BtS partners helped generate a focus on articulation between high school proficiency measures and the City College of San Francisco into student placements in remedial and nonremedial courses. This targeted focus enabled concrete actions, such as the formation of pilots that enable more students to place into courses that accrue college credit.

YDA has also pioneered a set of novel methodologies that support productive use and visualization of data. For example, YDA partnered with community leaders in the city of East Palo Alto and the Belle Haven neighborhood in San Mateo County, California, to map the supply and demand of out-of-school time (OST) activities for youth (Castrechini & Ardoin, 2011). With help from partners, YDA staff compiled a list and interviewed OST providers. The project also engaged a group of local youth to gather and analyze data from other youth about their program preferences and typical location after school. Maps were constructed that included the location of OST activities, concentrations of youth, transit lines, and census data such as "crime hotspots." Visualizing youth survey data in relation to program availability illuminated some potential gaps between OST activity supply and demand. Methodologically, this project also reflects YDA's commitment to the active engagement of community partners in the research process as a mechanism to promote pursuit of actionable and relevant questions. In addition, engaging youth likely contributed to the collection of more accurate data about youth preferences and attitudes.

Another example of a novel methodology that supports productive use and visualization of data is YDA's "event histories" of youth. To model and trace youth's participation across settings, YDA analysts match individual-level data across programs and over time, which results in event histories that provide an integrated portrait of program participation

(McLaughlin & O'Brien-Strain, 2008). Event history data can be displayed visually and provide context for assessing the full set of services and opportunities for youth in a community, including how they might be better coordinated. Moreover, it provides a "boundary object" (Star & Griesemer, 1989) around which diverse stakeholders can visualize, discuss, and make sense of the integrated data.

SUMMARY

The work of YDA highlights theoretical approaches and methodologies that aim to support productive work across sectors. Conceptualizing youth development and learning as stretched across a range of settings and institutions enables YDA to engage community partners in iterative, collaborative design that breaks down boundaries between typically disconnected settings and services. Theories of effective data use, coupled with novel methodologies for making sense of data across sectors, enable diverse stakeholders to collaborate in order to improve a region's capacity for youth development.

CASE 3: MIDDLE SCHOOL MATHEMATICS AND THE INSTITUTIONAL SETTING OF TEACHING

The third guiding principle of DBIR is that it is concerned with "developing theory related to both classroom learning and implementation through systematic inquiry" (Penuel et al., 2011, p. 332). Here, we turn to the Middle School Mathematics and the Institutional Setting of Teaching (MIST) project (see Cobb, Jackson, Smith, Sorum, & Henrick, 2013, this Yearbook) as an example of a project that is centrally concerned with developing, testing, and refining theory regarding the improvement of middle-grades mathematics instruction in large U.S. school districts. In brief, the MIST project entails annual cycles in which researchers interview district leaders to document each district's set of strategies for improving middle-grades mathematics; collect a wide range of data on how the strategies are playing out in schools and classrooms; analyze the data to account for whether the implemented strategies diverge from the designed strategies and, if so, how and why; and provide feedback to district leaders about the findings and make actionable recommendations regarding how strategies might be adjusted for the following year.

DEVELOPING, TESTING, REFINING, AND ELABORATING A THEORY OF ACTION FOR IMPROVING MIDDLE-GRADES MATHEMATICS

A central goal of MIST is the development of a theory of action (Argyris & Schön, 1974, 1978) for instructional improvement in middle-grades

mathematics, particularly in large U.S. school districts. Argyris and Schön (1978) explained theories of action this way: "Theories created to understand and predict may be quite different from theories created to help people make events come about. The latter, which we have called theories of action, must lead to understanding and prediction, but they must go beyond these two important functions" (p. 4). Theories of action must also produce solutions to problems, argued Argyris and Schön. Another way of characterizing theories of action is to say that they are intended to be explanatory and predictive, as well as a theory of control:

> An explanatory theory explains events by setting forth propositions from which these events may be inferred, a predictive theory sets forth propositions from which inferences about future events may be made, and a theory of control describes the conditions under which events of a certain kind may be made to occur. (Argyris & Schön, 1974, p. 5)

In MIST's case, the theory of action is intended to guide district leaders in designing policies, or strategies, to improve middle-grades mathematics instruction (given particular conditions that characterize most large urban districts); however, it is also intended to serve as a tool to explain why particular strategies may or may not achieve the intended results.

It is important to note that any theory of action must specify as its referent a particular set of goals. In Phase I of the MIST project (2007–2011), researchers were purposeful in recruiting four districts that shared a set of goals for students' mathematics learning (to develop conceptual understanding of key mathematical ideas and procedural fluency) and a corresponding vision of high-quality mathematics instruction (e.g., instruction in which students solve complex tasks, frequent opportunities for students to explain and justify their reasoning). This set of goals for students' learning and vision of high-quality mathematics instruction grounds the emerging theory of action, and it shapes how the team approaches the phenomena of interest (improving instruction at the scale of large districts) theoretically and methodologically.

In Argyris and Schön's (1974) terms, MIST researchers identify district leaders' local, espoused theories for instructional improvement in mathematics, compare those with the theories-in-use, and provide feedback and recommendations to the district leaders on how to adjust their espoused theories to make them more effective (i.e., achieve the intended goals). A pragmatic goal of MIST is to support the capacity of the participating district leaders to evaluate and refine their local theories of action for instructional improvement in middle-grades mathematics. However, MIST's purpose is not only to support the instructional improvement efforts in the four participating districts; instead, the annual cycles (in

addition to longitudinal analyses) serve as a context for the MIST researchers to test, refine, and elaborate an empirically grounded theory of action for improving the quality of instruction at the scale of large U.S. school districts. This theory of action is intended to generalize to other districts pursuing reform in middle-grades mathematics, given a set of assumptions (e.g., specific goals for students' learning, specific vision of high-quality mathematics instruction—or what one might think of as specific goals for teachers' learning) and conditions (e.g., large numbers of novice teachers, persistent disparities in subgroups of students' performance on state mathematics assessments). The current iteration of the theory of action, based on findings in Phase I, consists of five interrelated components that range from classroom supports (e.g., curriculum materials), to teacher professional development, to coaches', school leaders', and district leaders' practices (see Cobb & Jackson, 2011, for a full description). In Phase II of the project (2011–2015), the research team is working with two of the original four districts to further test, elaborate, and refine the theory of action.

BRIDGING AND ADAPTING LITERATURES ON LEARNING AND IMPLEMENTATION TO INFORM THEORY-BUILDING AND METHODOLOGIES

MIST illustrates the necessity of bridging multiple literatures when theorizing instructional improvement at scale. The emergent theory of action is informed by a number of literatures spanning teacher learning, mathematics education, implementation, and educational policy. At its core, MIST is concerned with teacher learning. As is typical of most middle-grades mathematics teaching in the United States (Stigler & Hiebert, 1999), teachers in the participating districts tended to teach mathematics aimed at developing students' procedural understandings of mathematics at the expense of conceptual understandings. Achieving the guiding vision of instruction therefore required the radical reorganization of most of the teachers' current practices and therefore involved significant learning on the part of teachers. MIST researchers therefore drew heavily on the literature that theorizes the development of complex practices (Lave & Wenger, 1991), some of which is specific to (mathematics) teachers' development of ambitious practice (Ball, Sleep, Boerst, & Bass, 2009; Kazemi, Franke, & Lampert, 2009; Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). These literatures suggest the importance of novices coparticipating in both the investigation and enactment (Grossman et al., 2009) of activities central to teaching mathematics with others who have relevant expertise. As an example, the current theory of action emphasizes the importance of teachers having sustained opportunities to

investigate and enact high-leverage aspects of teaching (e.g., analyzing student work, planning for a concluding whole-class discussion, leading a whole-class discussion) with a person who is already relatively accomplished in teaching (e.g., a coach).

However, MIST researchers approached the theorization of supporting teacher learning as also involving learning on the part of other role groups, including coaches, school leaders, and district leaders. Efforts to support teacher learning suggest that what teachers do is profoundly shaped by the contexts in which they teach (Bryk, Sebring, Allensworth, Luppesco, & Easton, 2010; Cobb, McClain, Lamberg, & Dean, 2003; Coburn, 2003; Elmore, 2004); solely focusing on teachers' learning is inadequate when theorizing the improvement of instruction at scale. That said, literature that theorizes the learning, or development of repertoires for participation in complex practices, of other role groups—for example, principals or coaches—is thin. Therefore, MIST adapted theories of teachers' learning to theorize the learning of other role groups. For example, the current theory of action specifies that observing and providing feedback that communicates instructional expectations specific to high-quality mathematics instruction is a high-leverage practice for principals. An assumption is that developing this form of practice is nontrivial on the part of principals; it requires the reorganization of their current practices. Therefore, the current iteration of the theory of action suggests that just as teachers need scaffolded opportunities to both investigate and enact high-leverage practices with a more expert other, so do principals. For example, the theory of action suggests that it is important that principals are provided with scaffolded opportunities to analyze instruction and learn and practice how to provide targeted feedback with a more expert other, ideally a math coach and/or a district leadership specialist.

In addition to adapting theories of teacher learning to other role groups, MIST researchers drew from theoretical perspectives most often the province of implementation research. As an example, social capital theory (Lin, 2001; Portes, 1998) has contributed to MIST's development of theory regarding the role of the institutional context in implementing ambitious reforms, particularly in theorizing the role of teacher networks in instructional improvement efforts. Research suggests that social networks are both a resource for, and a product of, instructional improvement (e.g., Coburn, 2001; Coburn & Russell, 2008; Penuel, Riel, Krause, & Frank, 2009). Within the organization of the school, teachers can learn from others in their local contexts who have adapted innovations given similar students, other curricular elements, and additional aspects of the organizational context and who have an interest in supporting others (Frank, 2009; Frank, Zhao, & Borman, 2004).

Given the literature on the importance of social networks in supporting instructional improvement at scale, MIST team researchers administered social network surveys to all 300 math teachers across the 30 schools in the study during Years 2–4 of Phase I of the project. Researchers conducted a series of quantitative social network analyses, focusing on the structural features of networks (e.g., nature of ties, frequency of interactions) and resources available from network members (e.g., expertise). Outcomes that were modeled as functions of the network included assessments of teachers' mathematical knowledge for teaching (Hill, Schilling, & Ball, 2004) and the quality of teachers' instructional practices (Boston, 2012). The social network analyses have suggested that the presence of one or more teachers who have already developed relatively accomplished practices in a network appears to be crucial in supporting improvement (Sun & Frank, 2011). Teachers' interactions with more accomplished colleagues are related to significant improvements in their mathematical knowledge for teaching and in the quality of their instructional practices. Furthermore, the level of sophistication of the practices of the most accomplished teacher in a school is related to overall improvement in the quality of instruction in the school (Sun & Frank, 2011).

Given these findings, in the current iteration of the theory of action, MIST researchers emphasize the importance of designing conditions in which teacher networks might develop for two reasons. First, the development of dense networks might indicate that teachers trust one another and hold each other accountable for supporting student learning, both of which are important in sustaining improvement in instructional practice (Bryk & Schneider, 2002; Penuel et al., 2009). Second, teacher networks may provide teachers with access to expertise. That said, the extent to which teachers actually access one another's expertise depends crucially on the nature of activities in which they engage with one another (Coburn & Russell, 2008).

An understanding of the mechanisms underlying a "network effect" can be enhanced by employing qualitative methods, which enable nuanced attention to the content of actors' interactions in networks related to their negotiation of new practices. Directly investigating the content of interactions has the potential to provide further insight into the mechanisms through which social networks influence implementation. For example, in a study of one district's implementation of reform mathematics curriculum, Coburn and colleagues (Coburn & Russell, 2008; Coburn, Russell, Kaufman, & Stein, 2012) found that access to social networks characterized by a high level of mathematics teaching expertise, strong ties, and high-depth interactions (e.g., interactions focused on substantive

issues related to mathematics and pedagogy) supported teachers' sustained enactment of reform mathematics strategies. In particular, teachers who had more substantive interactions with coaches had opportunities to develop nuanced understandings of reform strategies. As such, the "routines of interaction" between coaches and teachers explained the role social networks played in deepening teachers' enactment of reform strategies. More generally, qualitative analyses that unpack the content of educators' interactions contribute to DBIR endeavors by providing insight into the mechanisms underlying social network transactions, revealing *how* the nature of interactions can be a resource or impediment to the implementation of designed improvement efforts.

ADAPTING CLASSROOM DESIGN-RESEARCH METHODOLOGIES

As described in detail elsewhere (Henrick, Cobb, & Jackson, in press), MIST has adapted classroom-based design-research methods to study, theorize, and contribute to instructional improvement at the scale of large urban districts. In typical classroom-based design research, researchers develop, test, and refine theories related to how an intervention can improve student learning. The researchers typically design the particular intervention and may implement or collaborate with the classroom teacher in implementing the intervention. Design cycles are often at the timescale of a lesson (1 day of instruction). Theory building tends to focus on students' learning and the conditions necessary for supporting that learning (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003).

DBIR entails the development, testing, and refinement of theories related to improving the implementation of a particular intervention (Penuel et al., 2011). In MIST, the "intervention" involved the set of strategies that district leaders designed to improve the quality of middle-grades mathematics instruction. The researchers did not design or implement the intervention themselves. Instead, they studied the implementation of the district leaders' designs. Additionally, MIST design cycles were at the timescale of a school year, as opposed to the daily cycle often used in classroom-based design research. This is because district leaders tend to design their strategies for improving classroom instruction in summer and then readjust them the following summer.

With these kinds of adaptations, design-based research is particularly well suited to studying and contributing to instructional improvement at scale. As Cobb, Confrey et al. (2003) wrote, in design-based research, "The intent is to investigate the possibilities for educational improvement by bringing about new forms of learning in order to study them" (p. 10). In the case of MIST, by providing feedback and recommendations specific to the district's enacted strategies, the researchers were in a position to influence district leaders' adjustment of strategies. As the MIST

team reports in this Yearbook, district leaders acted on the recommendations to a remarkable degree. Researchers were therefore in a position to study the consequences of revising particular supports for role groups' learning the following year. The iterative design cycles in four districts allowed the team to place their current "theories in harm's way" (Cobb, Confrey, et al., 2003, p. 10), thereby allowing for the testing, refinement, and elaboration of a more generalizable theory of action for instructional improvement in mathematics.

SUMMARY

MIST illustrates a number of principles and practices in theorizing instructional improvement at scale that are likely to be of use to others engaged in design-based implementation research. First, the project illustrates the value in organizing empirical research to develop, test, refine, and elaborate a theory of action. Second, it illustrates the value of bridging and adapting literatures—for example, teacher learning and implementation—that have traditionally remained somewhat siloed. Third, it illustrates the value of adapting classroom design-research methodologies to studying and contributing to instructional improvement at scale.

CASE 4: THE STRATEGIC EDUCATION RESEARCH PARTNERSHIP

The fourth guiding principle of DBIR is that it is concerned with "developing capacity for sustaining change in systems" (Penuel et al., 2011, p. 332). Here, we turn to the Strategic Education Research Partnership (SERP; see Donovan, Snow, & Daro, 2013, this Yearbook) as an example of a partnership model that is centrally concerned with developing infrastructure to support practitioners, researchers, and designers to collaboratively address significant problems of practice. As Donovan et al. (2013, this Yearbook) clarify, SERP's short-term goal is to address problems of practice and positively impact student achievement. However, SERP's long-term goal is to support a fundamentally different working relationship between researchers, practitioners, and designers aimed at supporting the development of ways of working, knowledge, and tools that support sustained educational improvement.

The SERP model is distinct from conventional researcher–practitioner collaborations. Local and national SERP staff coordinate work in the "field sites," which are "ongoing partnerships with school districts in which the norms and routines of collaboration evolve with experience and become deeply rooted over time" (Donovan, 2011, pp. 1–2). District leaders drive the effort to identify and propose the focal problem of practice. Researchers are recruited to participate in a particular field site to address a specific problem because they bring targeted expertise to the

work. This contrasts with typical researcher–practitioner relationships, in which researchers approach practitioners to study a phenomenon, pilot an intervention, test a theory, and so forth. As Snow and Donovan (2011) wrote, "If educational research is to be relevant to practice, it does not have the luxury of starting from theory. Rather, educational researchers should be willing to take on the issues seen as most pressing by practitioners themselves" (pp. 4–5). Researchers then engage in the design of interventions specific to the problem of practice, and practitioners field test the interventions and provide feedback regarding usability and efficacy to the designers, who in turn refine the intervention (Snow & Donovan, 2011).

GROUNDING THE DESIGN OF INTERVENTIONS IN THEORIES OF LEARNING AND IMPLEMENTATION

Similar to Carnegie and MIST, the work of SERP draws from theoretical perspectives specific to individuals' academic learning in particular content areas as well as literature regarding school reform that is more generally the province of educational leadership and policy. The nature of the theoretical perspectives or bodies of literature specific to learning that impact the design of any given intervention depends, of course, on the nature of the focal problem of practice. Any designed SERP intervention is grounded in goals for students' learning of a particular skill or concept and informed by theory and literature specific to learning that skill or concept.

For example, in one of the field sites, Boston Public Schools (BPS), SERP partners designed and implemented the Word Generation program in response to district leaders' identification of challenges in literacy achievement in the middle grades. The Word Generation program focuses on students' development of academic vocabulary across various content areas. It consists of "a set of activities designed to ensure that middle grades students learned all-purpose academic words by encountering them in authentic texts, and having opportunities to use them in math, history, and science as well as in English language arts reading and writing activities" (Snow & Donovan, 2011, pp. 10–11). The orientation and design of the Word Generation program are grounded in what the research on language and literacy learning suggested would support middle-grades students' development of academic vocabulary (Snow, Uccelli, & White, in press).

Theories regarding educational reform, educational policy, and organizational learning also inform the SERP design of particular instructional interventions (Snow & Donovan, 2011). In SERP, theories about the importance of internal coherence at the school level (Abelman, Elmore,

Even, Kenyon, & Marshall, 1999; City, Elmore, Fiarman, & Teitel, 2009) have been especially influential. Internal coherence is defined as "a school's capacity to engage in deliberate improvements in instructional practice and student learning across classrooms over time" (Elmore, Forman, Stosich, & Bocala, 2012, p. 2). It includes three aspects identified as crucial in the school improvement literature: "leadership focused on the support for instructional improvement, individual and collective efficacy beliefs of faculty related to instructional practice and student learning, and the whole school and team-level organizational structures and processes that support improved instruction and student achievement over time" (SERP, 2012; see also Elmore et al., 2012). On the premise that improved internal coherence of schools is likely to result in better implementation, the SERP design group associated with the Word Generation program proposed that the school organization experts design an instrument to help differentiate high- and low-coherence schools (SERP, 2012). Under Elmore's direction, experts in school organization and educational reform designed an "internal accountability instrument" to place schools on a developmental continuum of internal coherence. An important note is that assessments of schools' internal coherence impact design decisions made in the context of the SERP work.

SERP's efforts to improve internal coherence are grounded in organized work aimed at helping schools align the goals and strategies for instructional improvement (Elmore et al., 2012). For example, based on results using the internal accountability instrument, SERP partners worked closely with "low coherence schools" to implement the Word Generation program and, at the same time, to improve their overall internal coherence. In other words, the Word Generation program served as a vehicle to both ground and support efforts at improving internal coherence more generally. Word Generation included more traditional forms of teacher support (e.g., teacher guides, professional development); however, it was also purposefully designed to foster collaboration among teachers and to be dependent on administrator support. For example, it was "designed to be implemented by grade-level teams sharing responsibilities because lessons were distributed across the days of the week—a design feature that incidentally imposed the need for grade-level teams to communicate about scheduling" (Snow & Donovan, 2011, p. 8). In addition, SERP designed professional development for school leaders that examined the school profiles generated by assessments of schools' internal coherence (Elmore et al., 2012). More generally, SERP partners have suggested that because Word Generation is designed to be enacted across subject areas and "provide[s] the opportunity to work toward a shared goal," it is a useful vehicle for improving internal coherence (SERP, 2012).

BUILDING INFRASTRUCTURE TO SUPPORT PRODUCTIVE WORK ACROSS RESEARCHERS AND PRACTITIONERS

One of the unique features of SERP is how SERP staff deliberately build infrastructure that supports productive work across researchers and practitioners. For example, each field site is coordinated by a core group that is jointly led by district leaders, lead researchers, and SERP staff and that is charged with deciding the overall direction for the field site's work, including the selection of a focal problem of practice. This design choice is motivated by recognition that authority relationships have forestalled prior efforts to bridge research and practice: District leaders lacked authority over the focus of the investigation, and researchers lacked authority over practice necessary to implement designs (Coburn, Bae, & Turner, 2008; Coburn & Stein, 2010). In SERP, the overall direction for the field site's work is selected primarily by practitioners who are expected to gain authority over the subsequent design and evaluation strategy, while researchers are given greater authority over instructional planning that is necessary to support implementation of new tools and interventions.

The team structure of SERP field sites aims to engineer social interactions that build capacity for system learning and the generation of novel solutions to systemic problems and to overcome some of the factors that typically prevent productive interaction between researchers and practitioners, such as asynchronous work practices and status differentials (Coburn & Stein, 2010; Grossman, Wineburg, & Woolworth, 2001). Depending on the nature of the problem selected by the core group, the research team and the design team are strategically selected to include problem-specific expertise, representing both learning and implementation issues. The research team is charged with working closely with local practitioners to learn about the nuances of the problem space and the nature of existing practice in a system. This process enables the research team to share critical knowledge about the problem and existing practice with the design team to inform their efforts to develop tools to support improvement. The research team and practitioners subsequently test and iteratively refine tools.

By creating what Coburn and Stein (2010) called "interactive spaces" in which researchers and practitioners engage in collaborative work, existing research understandings and knowledge of practice can inform the design of innovations that in turn enrich both practical knowledge and research understandings. Social capital theory suggests that the extent to which these interactive spaces result in productive interactions will depend on factors such as the development of relational trust, norms of interaction, shared commitment to a problem, and routines for

collaboration (Bryk & Schneider, 2002; Coburn & Russell, 2008; Moolenaar & Sleegers, 2010). The type of sustained engagement of researchers, practitioners, and designers envisioned by SERP organizers for the field sites may contribute to the development of such social capital. As such, the structuring of work to include practitioners, researchers, and designers engaged in joint work around key aspects of the reform goals enables the type of sustained and substantive interaction that can support system learning and the generation of novel solutions.

Building an infrastructure for high depth interaction among teams with diverse expertise also enables the recruitment of diverse methodologies. For example, in the case of Word Generation, different methodologies were employed at multiple stages of the design and intervention process. A design-based research approach was used to develop instructional tools (e.g., the Word Generation lessons) and interventions to support implementation (e.g., professional development for school leaders). Quasi-experimental methods were used to evaluate the initial effectiveness of the core instructional program and identify factors that support successful implementation such as professional development (a minimum of 4 hours before launch); strong leadership support (including accountability for practitioner engagement in implementation); faculty collaboration; and dedicated staff to coordinate the work in schools (e.g., collect writing samples, interface with designers, and oversee assessments; Snow, Lawrence & White, 2009). In addition, randomized controlled trials aimed to establish the efficacy of the Word Generation intervention at scale.

SUMMARY

SERP illustrates the value in grounding the design of interventions in both theories of learning and implementation, particularly if the goal is to improve student learning, teacher learning, and school capacity (Snow & Lawrence, 2011). For example, at the student level, the Word Generation program aims to build knowledge of high-frequency academic words. At the teacher level, the program aims to promote regular use of effective pedagogical strategies for teaching vocabulary, modeling comprehension, and promoting discussion in everyday instruction. At the school level, the program helps facilitate faculty collaboration across grades and content areas in service of instructional coherence. In addition, SERP illustrates productive ways in which to target the development of capacity for researchers and practitioners to collaboratively address problems of practice with high salience for local practitioners.

DISCUSSION

Throughout the chapter, we have highlighted theories and methods with potential for guiding DBIR-like work. For theories to have utility, they should provide a potential explanation for how designed tools or practices contribute to learning and/or how certain conditions support the implementation of those tools and practices in organizations and systems. For methods to have utility, they should be closely connected to the theoretical framing of the phenomena and inform the design of interventions, the study of implementation, and the refinement of interventions. In this section, we look across the four cases and make observations about theories and methods that are particularly well suited to DBIR. We begin by identifying some commonalities in the way these projects conceptualize learning, implementation, and/or organizational context; in doing so, we point to theories and/or characteristics of the projects' use of theory that may have utility beyond the individual cases profiled in this chapter. Similarly, we comment on the methodological approaches of these projects and explore the interplay between theories and methods.

At its core, DBIR is concerned with addressing persistent problems of teaching and learning. Therefore, theories of learning should play a central role in the design of interventions. The cases we explored each drew on learning theories that emphasize how the learning process is shaped by teaching and by being situated in particular social and organizational contexts. Of course, the selection/adaptation of appropriate theories of learning necessarily depends on the nature of the problem a project is addressing. However, as illustrated in the MIST case, theories that account for the learning of multiple role groups (e.g., students, teachers, administrators, professional development providers) have an especially important role to play in the design of interventions aimed at addressing persistent problems of teaching and learning.

The cases, particularly the Carnegie Pathways program and MIST, illustrate a productive characteristic of DBIR—the blending and adaptation of theories of learning (and with theories of organizational context and implementation) that are traditionally investigated in separate lines of research. For example, in the Carnegie Pathways program, given the focus on community college students' mathematics learning, the team drew on theories of the relationship between the tasks posed to students and students' opportunities to develop enduring understandings of mathematics (e.g., Stein & Lane, 1996). However, the Carnegie Pathways program also draws on theories of noncognitive factors that impact students' learning—for example, theories of motivation—in defining the focal problem of practice and subsequent design work. Theories of the relationship between mathematics instruction and student learning,

and content-neutral theories of motivation and engagement are rarely brought together in more traditional forms of research. More generally, a focus on addressing problems of practice—rather than solely contributing to academic knowledge, which tends to report to disciplinary boundaries—opens up the possibility of, and in fact likely demands, the integration and adaptation of theories of learning (and otherwise), if a problem is to be sufficiently addressed.

As we look across the four cases, we see commonalities in the way implementation is (or can be) conceptualized, which suggests that there may be a set of theoretical perspectives that are useful when understanding implementation in DBIR endeavors. First, social capital theory and network theory have the potential to explain how social structures can support productive collaboration for educational improvement. By definition, DBIR requires that practitioners, researchers, and designers work together to design and implement new materials and practices for learning. Theories of social capital and networks call attention to how interaction among people working across organizational boundaries enables the transfer of valued resources such as expertise, knowledge of practice, and even routines of interaction (Adler & Kwon, 2002; Coburn & Russell, 2008; Hansen, 1999; Reagans & McEvily, 2003). It also calls attention to the way that interactions can be structured for productive joint work, including opportunities for the development of strong ties through frequent interaction that engender trust and shared goals. Particular patterns of interaction have been associated with outcomes important to DBIR, such as transfer of complex information, diffusion of innovation, and reform implementation (Adler & Kwon, 2002; Frank et al., 2004; Penuel et al., 2009; Uzzi & Lancaster, 2003). This suggests that the social architecture that DBIR fosters is critical to the generation of new knowledge about learning and the implementation of new tools and practices.

In each of the cases, participants work across organizational boundaries to engage in collaborative design, implementation, and research. Theory that helps to unpack the complexity of interorganizational joint work is therefore relevant across projects. Theory suggests that this work requires coordination (Provan & Milward, 2005; Thomson & Perry, 2006; Thomson, Perry & Miller, 2007) and points to the role of a coordinating actor or organization (Bryk et al., 2011). Each of the cases we highlighted in this chapter had an organization that acted as a hub for the project, but each was positioned differently and took on a different role. Carnegie and SERP are both led by a hub organization that provides centralized coordination for the work of practitioners, designers, and researchers. The Gardner Center and the YDA project act as more of an intermediary than a centralized coordinator: They provide a service that enables the generation of new artifacts (integrated data) that

in turn enable community partners to work together to support youth development, but they do not directly drive the design effort. Similarly, MIST is positioned to be a critical friend to its partner districts but does not directly coordinate their instructional improvement work. Given that DBIR requires new roles for researchers and practitioners, it is possible to generate theory about these roles and relations and the conditions under which different organizational configurations are warranted or optimal.

In addition to providing explanations, theories in DBIR guide the selection of methodological strategies that include the identification of the core constructs, relationships, and hypotheses that will be systematically investigated. Looking across the four projects we have discussed reveals the value of a breadth of methodologies within DBIR. The work of DBIR encompasses many different kinds of tasks, from negotiating a problem space with diverse stakeholders, to the iterative design and testing of learning-focused interventions and plans for implementation. Accomplishing these different functions requires a range of methods. The cases highlighted in this chapter spotlight the use of improvement science routines, such as 90-day cycles and driver diagrams to map a problem space (Langley et al., 2009), the use of design-based research methods to generate and study new designs for learning (Cobb, Confrey, et al., 2003; Henrick et al., in press), and the use of survey-based research, randomized controlled trials, and qualitative case studies to elaborate theory and generate empirical findings about learning and implementation.

The cases also reveal the development of novel methodologies, particularly in the YDA case, that facilitate the transformation of data into knowledge for practice improvement. For example, event history and geo-spatial maps enable the visualization of the complex youth development field in ways that contribute to the design of planned change efforts. Work that brings together interdisciplinary teams including practitioners is bound to demand and give rise to novel methods and hybrid methodologies. Given this diversity of approaches, it becomes critical for the emerging DBIR community to establish and periodically refine standards for what constitutes rigorous methods and an evidentiary warrant for claims in the context of doing DBIR (see Means & Harris, 2013, this Yearbook, for a related discussion).

This Yearbook constitutes an important part of building DBIR as a field in that it brings together people engaged in similar work to reflect on similarities and differences in practices across projects. At present, teams, including the ones described here, are developing knowledge and practice of how to engage in DBIR at the same time that they are actually engaging in the work. A significant part of this work entails identifying

theories of learning, implementation, and organizational context (which are often initially unfamiliar to at least some of the researchers on the team) that do useful work; learning how to blend and/or adapt those theories given the specific problem of practice being addressed; and identifying ways to methodologically study the implementation of the intervention in robust ways, which often entails the creation of novel methods. The cases we analyzed in this chapter illustrate different, productive approaches to identifying, adapting, and developing theories and methods in an effort to support the development of common language, knowledge, practices, and tools that future researchers can use to engage in DBIR. We anticipate that these approaches will be enhanced as more researchers and practitioners collaborate to identify pressing problems of practice and to design and study interventions.

Acknowledgments

Jennifer Lin Russell and Kara Jackson contributed equally to the writing of this chapter. Kara Jackson's contributions to the chapter were supported in part by the National Academy of Education/Spencer Postdoctoral Fellowship Program. We would like to thank Barry Fishman, Bill Penuel, and Annie Allen for their helpful guidance and editorship throughout the writing of this chapter.

Notes

1. The software developer and inventor Douglas Engelbart first coined this term to refer to groups engaged in collective pursuits to improve a capability of a system, such as the ability of schools to provide powerful teaching and learning opportunities to all students. As Dolle et al. (2013, this Yearbook) note, the Pathways project extends Engelbart's ideas by developing specific methods for fostering NICs.
2. Carnegie employs the term practical theory to denote theory that has direct application to the practical considerations of design and implementation and that is meant to be interrogated and refined through experience in practice.

References

Abelman, C., Elmore, R., Even, J., Kenyon, S., & Marshall, J. (1999). *When accountability knocks, will anyone answer?* CPRE Research Report Series RR-42. Philadelphia: Consortium for Policy Research in Education, University of Pennsylvania, Graduate School of Education.

Adler, P. S., & Kwon, S. W. (2002). Social capital: Prospects for a new concept. *The Academy of Management Review*, *27*(1), 17–40.

Argyris, C., & Schön, D. (1974). *Theory in practice: Increasing professional effectiveness*. San Francisco, CA: Jossey-Bass.

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison Wesley.

Bailey, T., Jeong, D. W., & Cho, S. W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review, 29*(2), 255–270.

Ball, D. L., Sleep, L., Boerst, T., & Bass, H. (2009). Combining the development of practice and the practice of development in teacher education. *Elementary School Journal, 109*(5), 458–474.

Barron, B. (2006). Interest and self-sustained learning. *Human Development, 49*, 193–224.

Barron, B. (2010). Conceptualizing and tracing learning pathways over time and setting. *National Society for the Study of Education Yearbook, 109*(1), 113–127.

Beach, K. (1999). Consequential transitions: A sociocultural expedition beyond transfer in education. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of research in education* (pp. 101–139). Washington, DC: American Educational Research Association.

Becker, M. C. (2004). Organizational routines: A review of the literature. *Industrial and Corporate Change, 13*(4), 643–677.

Berwick, D. M. (2008). The science of improvement. *Journal of the American Medical Association, 299*(10), 1182–1184.

Boatman, A., & Long, B. T. (2010). *Does remediation work for all students? How the effects of postsecondary remedial and developmental courses vary by level of academic preparation* (NCPR working paper). New York, NY: National Center for Postsecondary Research.

Boston, M. D. (2012). Assessing the quality of mathematics instruction. *Elementary School Journal, 113*(1), 76–104.

Bowker, G. C., & Star, S. L. (1999). *Sorting things out: Classification and its consequences*. Cambridge, MA: MIT Press.

Bryk, A. (2009). Support a science of performance improvement. *Phi Delta Kappan*, *90*(8), 597–600.

Bryk, A. S., Gomez, L. M., & Grunow, A. (2011). Getting ideas into action: Building networked improvement communities in education. In M. Hallinan (Ed.), *Frontiers in sociology of education* (pp. 127–162). New York, NY: Springer.

Bryk, A. S., & Schneider, B. (2002). *Trust in schools: A core resource for improvement*. New York, NY: Russell Sage Foundation.

Bryk, A. S., Sebring, P. B., Allensworth, E., Luppesco, S., & Easton, J. Q. (2010). *Organizing schools for improvement: Lessons from Chicago*. Chicago, IL: University of Chicago Press.

Calcagno, J. C., & Long, B. T. (2008). *The impact of postsecondary remediation using a regression discontinuity approach: Addressing endogenous sorting and noncompliance* (NBER Working Paper No. 14194). Cambridge, MA: National Bureau of Economic Research.

Carnegie Foundation for the Advancement of Teaching. (2012a). *Carnegie pathways mean success for developmental math students* (Press release). Palo Alto, CA: Author.

Carnegie Foundation for the Advancement of Teaching. (2012b). *Improvement research*. Retrieved from http://www.carnegiefoundation.org/improvement-research/approach

Castrechini, S., & Ardoin, N. M. (2011). Youth resource mapping: Partnering with service providers and youth to understand the supply and demand for youth services in a local context. *Perspectives on Urban Education*, *8*(2), 3–11.

City, E. A., Elmore, R., Fiarman, S. E., & Teitel, L. (2009). *Instructional rounds in education*. Cambridge, MA: Harvard Education Press.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational Researcher, 32*(1), 9–13.

Cobb, P., & Jackson, K. (2011). Towards an empirically grounded theory of action for improving the quality of mathematics teaching at scale. *Mathematics Teacher Education and Development, 13*(1), 6–33.

Cobb, P., Jackson, K., Smith, T., Sorum, M., & Henrick, E. (2013). Design research with educational systems: Investigating and supporting improvements in the quality of mathematics teaching and learning at scale. *National Society for the Study of Education Yearbook*, *112*(2), 320–349.

Cobb, P., McClain, K., Lamberg, T., & Dean, C. (2003). Situating teachers' instructional practices in the institutional setting of the school and district. *Educational Researcher, 32*(6), 13–24.

Coburn, C. E. (2001). Collective sensemaking about reading: How teachers mediate reading policy in their professional communities. *Educational Evaluation and Policy Analysis, 23*(2), 145–170.

Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher, 32*(6), 3–12.

Coburn, C. E., Bae, S., & Turner, E. O. (2008). Authority, status, and the dynamics of insider-outsider partnerships at the district level. *Peabody Journal of Education*, *83*(3), 364–399.

Coburn, C. E., & Russell, J. L. (2008). District policy and teachers' social networks. *Educational Evaluation and Policy Analysis, 30*(3), 203–235.

Coburn, C. E., Russell, J. L., Kaufman, J. & Stein, M. K. (2012). How teacher social capital shapes the implementation of innovative standards-based mathematics curricula. *American Journal of Education, 119*(1), 137–182.

Coburn, C. E., & Stein, M. K. (Eds.). (2010). *Research and practice in education: Building alliances, bridging the divide*. New York, NY: Rowman and Littlefield.

Coburn, C. E., & Talbert, J. E. (2006). Conceptions of evidence-based practice in school districts: Mapping the terrain. *American Journal of Education, 112*(4), 469–496.

Coburn, C. E., & Turner, E. O. (2012). The practice of data use: An introduction. *American Journal of Education, 118*(2), 99–111.

Cohen, M. D., & Bacdayan, P. (1994). Organizational routines are stored as procedural memory: Evidence from a laboratory study. *Organization Science, 5*(4), 554–568.

Colyvas, J. A. (2012). Performance metrics as formal structures through the lens of social mechanisms: When do they work and how do they influence? *American Journal of Education, 118*(2), 167–197.

Coombs, R., & Metcalfe, S. (2000). Organizing for innovation: Co-ordinating distributed innovation capabilities. In N. Foss & V. Mahnke (Eds.), *Competence, governance and entrepreneurship: Advances in economic strategy research* (pp. 209–231). Oxford, England: Oxford University Press.

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm*. Englewood Cliffs, NJ: Prentice Hall.

DiMaggio, P., & Powell, P. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(2), 147–160.

Dolle, J. R., Gomez, L. M., Russell, J. L., & Bryk, A. S. (2013). More than a network: Building professional communities for educational improvement. *National Society for the Study of Education Yearbook*, *112*(2), 443–463.

Donovan, M. S. (2011, April). *The SERP approach to research, design, and development: A different role for research and researchers*. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Donovan, M. S., Snow, C., & Daro, P. (2013). The SERP approach to problem-solving research, development, and implementation. *National Society for the Study of Education Yearbook*, *112*(2), 400–425.

Dreier, O. (2000). Psychotherapy in clients' trajectories across contexts. In C. Mattingly & L. C. Garro (Eds.), *Narrative and the cultural construction of illness and healing* (pp. 237–258). Berkeley: University of California Press.

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. *Journal of Personality and Social Psychology, 92*(6), 1087–1101.

Dweck, C. S., Walton, G. M., & Cohen, G. L. (2011). *Academic tenacity*. White paper prepared for the Gates Foundation, Seattle, WA.

Elmore, R. F. (2004). *School reform from the inside out*. Cambridge, MA: Harvard Education Press.

Elmore, R., Forman, M., Stosich, E. L., & Bocala, C. (2012). *Organizational capacity for instructional improvement: The IC Framework and Assessment Protocol*. Unpublished manuscript.

Engelbart, D. C. (2003, September). *Improving our ability to improve: A call for investment in a new future*. Paper presented at the IBM Co-Evolution Symposium, San Jose, CA.

Farrington, C., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T. S., Johnson, D., & Beechum, N. (2012). *Teaching adolescents to become learners: The role of noncognitive factors in shaping school performance: A critical literature review*. Chicago, IL: University of Chicago Consortium on Chicago School Research.

Feldman, M., & Pentland, B. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly, 48*(1), 94–121.

Feldman, M. S., & Rafaeli, A. (2002). Organizational routines as sources of connections and understandings. *Journal of Management Studies, 39*(3), 309–331.

Firestone, W. A., & Gonzalez, R. A. (2007). Culture and processes affecting data use in school. *National Society for the Study of Education Yearbook, 106*(1), 132–154.

Frank, K. A. (2009). Quasi-ties: Directing resources to members of a collective. *American Behavioral Scientist, 52*, 1613–1645.

Frank, K. A., Zhao, Y., & Borman, K. (2004). Social capital and the diffusion of innovations within organizations: The case of computer technology in schools. *Sociology of Education, 77*(2), 148–171.

Gawande, A. (2007). *Better: A surgeon's notes on performance*. New York, NY: Metropolitan Books.

Gawande, A. (2009). *Checklist manifesto: How to get things right*. New York, NY: Metropolitan Books.

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record, 111*(9), 2055–2100.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teachers College Record, 103*(6), 941–1012.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly, 44*(1), 82–111.

Heckman, J. J., & Kautz, T. (2012). Hard evidence on soft skills. *Labour Economics, 19*(4), 451–464.

Henrick, E., Cobb, P., & Jackson, K. (in press). Educational design research to support large-scale instructional improvement. In A. Bikner-Ahsbahs, C. Knipping, & N. C. Presmeg (Eds.), *Doing (qualitative) research: Methodology and methods in mathematics education*. New York, NY: Springer.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371–404). Charlotte, NC: Information Age.

Hiebert, J., & Wearne, D. (1993). Instructional tasks, classroom discourse, and students' learning in second grad arithmetic. *American Educational Research Journal, 30*, 393–425.

Hill, H. C., Schilling, S. G., & Ball, D. L. (2004). Developing measures of teachers' mathematics knowledge for teaching. *Elementary School Journal, 105*(1), 11–30.

Hodgson, G. M. (1993), *Economics and evolution*. Cambridge, England: Polity Press.

Huston, L., & Sakkab, N. (2006). Connect and develop: Inside Procter & Gamble's new model for innovation. *Harvard Business Review, 84*(3), 58–66.

Hutchins, E. (1995). How a cockpit remembers its speeds. *Cognitive Science, 19*(3), 265–288.

Jackson, K. (2011). Approaching participation in school-based mathematics as a cross-setting phenomenon. *Journal of the Learning Sciences, 20*(1), 111–150.

John W. Gardner Center. (2011, June). *Developing early warning indicators for the San Francisco Unified School District*. Youth Data Archive Issue Brief. Stanford, CA: John W. Gardner Center for Youth and Their Communities.

John W. Gardner Center. (2012). San Francisco's Bridge to Success (BtS). Retrieved from http://jgc.stanford.edu/our_work/bts.html

Kazemi, E., Franke, M. L., & Lampert, M. (2009). Developing pedagogies in teacher education to support novice teachers' ability to enact ambitious instruction. In R. Hunter, B. Bicknell, & T. Burgess (Eds.), *Crossing divides: Proceedings of the 32nd annual conference of the Mathematics Education Research Group of Australasia* (Vol. 1, pp. 12–30). Palmerston North, New Zealand: MERGA.

Knudsen, T. (2002). The significance of tacit knowledge in the evolution of human language. *Selection, 3*, 93–112.

Lampert, M. (2001). *Teaching problems and the problems in teaching*. New Haven, CT: Yale University Press.

Lampert, M., Beasley, H., Ghousseini, H., Kazemi, E., & Franke, M. L. (2010). Using designed instructional activities to enable novices to manage ambitious mathematics teaching. In M. K. Stein & L. Kucan (Eds.), *Instructional explanations in the disciplines* (pp. 129–141). New York, NY: Springer.

Langley, G., Moen, R., Nolan, K., Nolan, T., Norman, C., & Provost, L. (2009). *The improvement guide* (2nd ed.). San Francisco, CA: Jossey-Bass.

Langlois, R. N. (1992). Transaction-cost economics in real time. *Industrial and Corporate Change, 1*, 99–127.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. London, England: Cambridge University Press.

Lin, N. (2001). *Social capital: A theory of social structure and action*. New York, NY: Cambridge University Press.

Little, J. W. (2012). Understanding data use practice among teachers: The contribution of micro-process studies. *American Journal of Education*, *118*(2), 143–166.

March, J., & Simon, H. (1958). *Organizations*. New York, NY: Wiley.

Massoud, M. R., Nielsen, G. A., Nolan, K., Nolan, T., Schall, M. W., & Sevin, C. (2006). *A framework for spread: From local improvements to system-wide change* (IHI Innovation Series white paper). Cambridge, MA: Institute for Healthcare Improvement.

McLaughlin, M., & London, R. (2013). Taking a societal sector perspective on youth learning and development. *National Society for the Study of Education Yearbook*, *112*(2), 192–214.

McLaughlin, M., & O'Brien-Strain, M. (2008). The Youth Data Archive: Integrating data to assess social settings in societal sector. In M. Shinn & H. Yoshikawa (Eds.), *Toward positive youth development: Transforming schools and community programs* (pp. 313–332). New York, NY: Oxford University Press.

McLaughlin, M., & Talbert, J. (2001). *Professional communities and the work of high school teaching*. Chicago, IL: University of Chicago Press.

Means, B., & Harris, C. (2013). Towards an evidence framework for design-based implementation research. *National Society for the Study of Education Yearbook*, *112*(2), 350–371.

Means, B., Padilla, C., DeBarger, A., & Bakia, M. (2009). *Implementing data-informed decision making in schools: Teacher access, supports and use*. Washington, DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development.

Means, B., Padilla, C., & Gallagher, L. (2010). *Use of educational data at the local level: From accountability to instructional improvement*. Washington, DC: U.S. Department of Education, Office of Planning, Evaluation, and Policy Development.

Moolenaar, N. M., & Sleegers, P. J. C. (2010). Social networks, trust, and innovation: The role of relationships in supporting an innovative climate in Dutch schools. In A. J. Daly (Ed.), *Social network theory and educational change* (pp. 97–114). Cambridge, MA: Harvard University Press.

Moss, P. A. (2012). Exploring the macro-micro dynamic in data use practice. *American Journal of Education*, *118*(2), 223–232.

Nelson, R. R. (1994). Routines. In G. Hodgson, W. Samuels, & M. Tool (Eds.), *The Elgar companion to institutional and evolutionary economics* (Vol. 2, pp. 249–253). Aldershot, England: Edward Elgar.

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

Nelson, T. H., Slavit, D., & Deuel, A. (2012). Two dimensions of an inquiry stance toward student-learning data. *Teachers College Record*, *114*, 1–42.

Nolan, K., Schall, M. W., Erb, F., & Nolan, T. (2005). Using a framework for spread: The case of patient access in the Veterans Health Administration. *Journal on Quality and Patient Safety, 31*(6), 339–347.

Pentland, B. T., & Reuter, H, (1994). Organizational routines as grammars of action. *Administrative Science Quarterly, 39*, 488–510.

Penuel, W. R., Fishman, B. J., Cheng, B. H., & Sabelli, N. (2011). Organizing research and development at the intersection of learning, implementation, and design. *Educational Researcher, 40*(7), 331–337.

Penuel, W. R., Frank, K. A., & Krause, A. (2010). Between leaders and teachers: Using social network analysis to examine the effects of distributed leadership. In A. J. Daly (Ed.), *Social network theory and educational change* (pp. 159–178). Cambridge, MA: Harvard University Press.

Penuel, W. R., Riel, M., Krause, A., & Frank, K. A. (2009). Analyzing teachers' professional interactions in a school as social capital: A social network approach. *Teachers College Record, 111*(1), 124–163.

Portes, A. (1998). Social capital: Its origins and applications in modern sociology. *Annual Review of Sociology, 24*, 1–24.

Provan, K. G., & Milward, H.B. (1995). A preliminary theory of interorganizational network effectiveness: A comparative study of four community mental health systems. *Administrative Science Quarterly, 40*(1), 1–33.

Reagans, R., & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly, 48*(2), 240–267.

Rowan, B. (2002). The ecology of school improvement: Notes on the school improvement industry in the United States. *Journal of Educational Change*, *3*, 283–314.

Scott, W. R., Deschenes, S., Hopkins, K., Newman, A., & McLaughlin, M. (2006). Advocacy organizations and the field of youth services: Ongoing efforts to restructure a field. *Nonprofit and Voluntary Sector Quarterly, 35*(4), 697–714.

Sherer, J. Z., & Spillane, J. P. (2011). Constancy and change in school work practice: Exploring the role of organizational routines. *Teachers College Record, 113*(3), 611–657.

Snow, C., & Donovan, M. S. (2011). *The Strategic Education Research Partnership: A new approach to educational research*. Unpublished manuscript. Retrieved from http://www.serpinstitute.org/tools-and-resources/presentations.php

Snow, C., Lawrence, J., & White, C. (2009). Generating knowledge of academic language among urban middle school students. *Journal of Research on Educational Effectiveness, 2*(4), 325–344.

Snow, C. E., & Lawrence, J. F. (2011). Word Generation in Boston Public Schools: Natural history of a literacy intervention. *The senior urban education research fellowship series* (Vol. 3). Washington, DC: Council of the Great City Schools.

Snow, C., Uccelli, P., & White, C. (in press). The conditions for and significance of children's acquisition of academic language. In C. Rosebrock & A. Bertschi-Kauffman (Eds.), *Capturing literacy: Educationally, culturally, and individually*. Weinhelm, Germany: Beltz Juventa.

Spillane, J. P. (2012). Data in practice: Conceptualizing the data-based decision-making phenomena. *American Journal of Education, 118*(2), 113–141.

Spillane, J., Gomez, L., & Messler, L. (2009). Notes on reframing the role of organizations in policy implementation: Resources *for* practice, *in* practice. In G. Sykes, B. Schneider, & D. N. Plank (Eds.), *Handbook of education policy research* (pp. 409–425). New York, NY: Routledge.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39. *Social Studies of Science, 19*(3), 387–420.

Stein, M. K., Grover, B. W., & Henningsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal, 33*(2), 455–488.

Stein, M. K., & Lane, S. (1996). Instructional tasks and the development of student capacity to think and reason: An analysis of the relationship between teaching and learning in a reform mathematics project. *Educational Research and Evaluation, 2*(1), 50–80.

Stevens, R., Satwicz, T., & McCarthy, L. (2008). In-game, in-room, in-world: Reconnecting video game play to the rest of kids' lives. In K. Salen (Ed.), *The ecology of games* (pp. 41–66). Cambridge, MA: MIT Press.

Stigler, J., & Hiebert, J. I. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom.* New York, NY: Free Press.

Strategic Education Research Partnership. (2012). *Building coherence within schools*. Retrieved from http://ic.serpmedia.org/

Sun, M., & Frank, K. (2011, April). *Peer's influence on teachers' mathematical knowledge for teaching and instructional practices.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Thomson, A. M., & Perry, J. L. (2006). Collaboration processes: Inside the black box. *Public Administration Review, 66* (s1), 20–32.

Thomson, A., Perry, J. L., & Miller, J. K. (2007). Conceptualizing and measuring collaboration. *Journal of Public Administration Research and Theory, 19*, 23–56.

Tough, P. (2012). *How children succeed: Grit, curiosity, and the hidden power of character*. Boston, MA: Houghton Mifflin Harcourt.

Tyre, M. J., & Orlikowski, W. J. (1996). The episodic process of learning by using. *International Journal of Technology Management, 11*, 790–798.

Uzzi, B., & Lancaster, R. (2003). Relational embeddedness and learning: The case of bank loan managers and their clients. *Management Science, 49*(4), 383–399.

Weick, K. E., & Roberts, K. H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(3), 357–381.

Weitzman, B. C., Silver, D., & Brazill, C. (2006). Efforts to improve public policy and programs through improved data practices: Experiences in 15 distressed American cities. *Public Administration Review*, 6(3), 386–399.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York, NY: Cambridge University Press.

Wortham, S. (2006). *Learning identity: The joint emergence of social identification and academic learning*. New York, NY: Cambridge University Press.

Yeager, D. (2012a, April). *Practical measurement in action: Designing a new measure of community college student motivation and engagement.* Paper presented at the annual meeting of the American Educational Research Association, Vancouver, British Columbia, Canada.
Yeager, D. (2012, March). *Productive persistence: Tenacity + good strategies*. Presentation at the Achieving the Dream Annual Meeting on Student Success, Dallas, TX.
Yeager, D. S., & Walton, G. (2011). Social-psychological interventions in education: They're not magic. *Review of Educational Research, 81*, 267–301.

JENNIFER LIN RUSSELL is an assistant professor of education policy and organizations in the School of Education and a research scientist at the Learning Research and Development Center at the University of Pittsburgh. Her research examines policy and other educational improvement initiatives through an organizational perspective. Recent publications include: "From child's garden to academic press: The role of shifting institutional logics in redefining kindergarten education" (2011, *American Educational Research Journal*); and "Crafting coherence from complex policy messages: Educators' perceptions of special education and standards-based accountability policies" (2013, *Education Policy Analysis Archives*) with L. E. Bray.

KARA JACKSON is an assistant professor at the University of Washington, Seattle. Her research focuses on identifying forms of practice that enable all learners to participate in rigorous mathematics and on supporting teachers' development of these forms of practice. Recent publications include "Exploring relationships between setting up complex tasks and opportunities to learn in concluding whole-class discussions in middle-grades mathematics instruction" (2013, *Journal for Research in Mathematics Education*) with Anne Garrison, Jonee Wilson, Lynsey Gibbons, and Emily Shahan and "Approaching participation in school-based mathematics as a cross-setting phenomenon" (2011, *Journal of the Learning Sciences*).

ANDREW E. KRUMM is an education researcher at SRI International in the Center for Technology in Learning. His research addresses factors affecting the implementation of learning technologies in educational organizations and the analysis of large user-generated data sets to support instructional decision-making. Recent publications include: "Enacting and justifying local reforms: Implications for understanding change in educational organizations" (2011, *Leadership and Policy in Schools)* with K. R. Holmstron.

KENNETH A. FRANK is a professor in counseling, educational psychology and special education as well as in fisheries and wildlife (and adjunct in sociology) at Michigan State University. His research interests concern how resources flow as innovations diffuse through social systems. Recent publications include: "The organization as a filter of institutional diffusion" (2013, *Teachers College Record*) by K. A. Frank,* W. R. Penuel,* M. Sun, C. Kim, & C. Singleton (*Authors listed alphabetically; equal authorship); and "Focus, fiddle and friends: Sources of knowledge to perform the complex task of teaching" (2011, *Sociology of Education*) with Y. Zhao, W. R. Penuel, N. C. Ellefson, and S. Porter.