CHAPTER 1

Design-Based Research in Educational Settings

Motivations, Crosscutting Features, and Considerations for Design

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> Most educational research describes or evaluates education as it currently is. Some educational research analyzes education as it was. Design research, however, is about education as it could be or even as it should be.
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> —BAKKER (2018, p. 3)

Design-based research (DBR) as it is practiced today can trace its origins to Vygotsky and his followers, as well as a number of other influences. One of those followers, Davydov (1988), coined the term *teaching experiment* to refer to a method he used: testing out approaches to supporting students' mathematical concept development, observing how students responded, and articulating potential trajectories of learning at the conclusions of his investigations. In the learning sciences, where DBR might be called a *signature methodology*, Davydov's approach inspired multiple lines of research in Holland and the United States in mathematics education (e.g., Cobb, McClain, & Gravemeijer, 2003). These researchers adapted the idea of a "teaching experiment" to the design and testing of conjectures about how to support mathematics learning. DBR within the learning sciences has also been inspired by participatory design traditions of Scandinavia (Ehn, 1992) and workplace ethnography (e.g., Orr & Crowfoot, 1992), and by psychologists and cognitive scientists seeking to create practical applications of theories and knowledge for education (e.g., Brown, 1992; Collins, 1992).

DBR is neither a single methodology nor a static one. It can be challenging to conceptualize, in part because it draws on methods from multiple traditions, from ethnography to human–computer interaction, and also because the purposes for DBR are so varied and continually evolving. For example, while DBR focused on

supporting subject matter learning during much of the decade of the 1990s, and typically involved close collaborations between researchers and one or more classroom teachers, today, DBR encompasses research on outcomes such as civic participation (Kirshner & Polman, 2013; York & Kirshner, 2015; York, 2015) and can involve multileveled partnerships between researchers and practitioners (Severance, Leary, & Johnson, 2014). Furthermore, whereas DBR has focused primarily in the past on generating powerful concepts about learning like Vygotsky's zone of proximal development (ZPD) that help us to *see* learning in new ways (diSessa & Cobb, 2004), today's DBR also aims to help us generate new forms of relationships—not only among researchers, practitioners, and community members, but also within larger ecosystems (Bang, Faber, Gurneau, Marin, & Soto, 2016).

When Is DBR a Good Choice as an Approach?

Before addressing what DBR *is*, it is useful to consider *when* DBR might be a good approach for a given problem, phenomenon, or goal. DBR, like all approaches to inquiry, can address some research questions more suitably than others (Bakker, 2018; Penuel & Frank, 2016). Furthermore, its pragmatic commitments to changing educational practice make it different from research that is primarily descriptive or critical in nature. DBR, however, can and does take critical perspectives (e.g., Khalil & Kier, 2017), and descriptive analyses are common in reports of design studies.

In this connection, one situation where DBR is a good choice is when the design team hopes to *intervene* in the situation. The purpose of intervention may be to improve an outcome that is already a goal within a school or community organization, but DBR is especially well suited to intervention where new goals are being identified and pursued that may not be reflected in current standards or practice (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Shaffer & Squire, 2006). The goals of intervention may also include transformation of systems (e.g., Wingert, Riedy, Campanella, & Penuel, 2020) and of relationships between institutions in a community (e.g., families and schools; Ishimaru & Takahashi, 2017).

Not all intervention research questions, however, can be addressed in DBR. When the question of whether something works or not is central, experimental research—in which participants or groups are randomly assigned to treatment or control conditions—is more appropriate to use than DBR. Experimental research answers the question of what would have happened if the participants did not participate in the intervention (cf. Rubin, 1974). By contrast, DBR answers questions of a "How can . . . ?" variety, such as *How can tools for assessment design help teachers develop more equitable assessments for students?* Causal questions can be answered, but they answer questions about the roles of designed tools and practices in supporting specific learning processes (Sandoval, 2014).

Another situation where DBR is a suitable approach is when the purpose is to develop theory and knowledge related to some aspect of learning and development.

Edelson (2002) wrote that DBR is a good approach for developing theory and knowledge related to particular outcomes of learning and routes or means to supporting learning. He also argued that DBR could help develop theory and knowledge related to how to go about designing a particular class of innovations. An example of this type of DBR comes from the inquiryHub partnership, which has iterated over many years on a process of collaborative design of science curriculum materials, with the purpose of refining an approach to balance a focus on standards with student interest (Penuel et al., 2018).

A review of the past two decades of DBR in education might lead one to conclude that DBR focuses exclusively on subject matter learning, particularly in science, technology, engineering, and mathematics (STEM). But DBR can be fitting for intervention research focused on any domain of learning and development at any age and in any context, from socioemotional learning of young children in preschools to the sociopolitical development of adolescents in community-based organizations to the civic learning of adults in a community science project in a museum. It can also be used to generate knowledge related to differences in values in a community of practitioners (Kaplan, Riedy, Van Horne, & Penuel, 2019).

Another occasion when DBR is appropriate is when researchers aim to directly affect practice through their research. At its core, DBR is pragmatic in aspiration (Brown, 1992), seeking to bring about changes in the world. Practical tools such as professional development (PD) designs and curriculum materials may result from DBR studies, even though those designs and materials are only sometimes shared widely. For some learning scientists, the pragmatic approach embedded in DBR means that designs should aspire to be usable within current contexts of learning (e.g., Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000). But for others, the goal of influencing practice is interpreted more in line with a Marxist or post-Marxist notion of *praxis* (e.g., Gutiérrez & Vossoughi, 2010). For these design researchers, it is not enough to support existing goals of institutions or even of researcher-developed learning goals; rather, DBR is oriented to support a kind of "social dreaming" (McLaren, 1991) of new possibilities not only for learning but also of a just society.

What Makes Something a Design Study?

In this section, we describe some crosscutting features of DBR. Our description differs from previous efforts to characterize what makes something a design study (e.g., Cobb et al., 2003; Design-Based Research [DBR] Collective, 2003; Reimann, 2011; Anderson & Shattuck, 2012), in that it both builds from those and derives from the collective effort of a group of graduate students to make sense of this broad, and continuing changing approach to research. The students read both earlier descriptions of DBR as an approach, as well as examples of DBR studies that have been widely cited in the field for decades and studies that have been published over the

last few years. The crosscutting features we describe below reflect their synthesis of key features, which extend earlier efforts at synthesis to encompass where DBR is headed as an approach in the learning sciences today.

DBR Is Future Oriented

DBR asks questions about what could be learned about the world by changing it. It asks what *could* or *should* be, and how can we get there? It seeks to imagine new possible social futures (New London Group, 1996) via the design or organization of learning environments. What could be goes beyond just the design of a particular program or curriculum: behind any DBR effort is a *design politic* (Tzou et al., 2019b), that is, an image of the social world as it could be and how to bring it about.

The particular imagined social futures and design politics of design researchers vary widely. Whereas some research posits subject-matter mastery as the desired end of learning and imagines that mastery at each grade level prepares students to develop successively more sophisticated understandings of subject matter (e.g., Wiser, Smith, & Doubler, 2012), other DBR raises significant questions about whether subject-matter learning as traditionally conceived can truly benefit people and communities in ways imagined (e.g., Bang, Warren, Rosebery, & Medin, 2012). Explicit commitments to equity and justice, to remediating and repairing relationships in human communities and with the Earth, as well as to cultural sustainability and resurgence, are increasingly goals of DBR (e.g., Bang et al., 2016; Bang & Vossoughi, 2016; Teeters & Jurow, 2018). Thus, the *design politic* of DBR can involve a critique of existing social and educational inequities, and it can also begin with an envisioning of radical new possibilities for learning.

Being future oriented also means that design researchers often invent methods for doing what has not yet been done in classrooms. For example, in the 1970s, mathematics teacher-researchers at the University of Utrecht in the Netherlands wanted students to have more control over their learning after years of top-down, direct instruction methods. They rejected existing educational research methods that began in controlled laboratory settings, which produced findings on a timeline that was too slow to be of practical use. They decided to set up shop in classrooms, testing their design ideas in real time and making immediate refinements. Over time, they developed a domain-specific theory, Realistic Mathematics Education (RME), which included both principles for math learning and for the design of math learning environments. This approach emphasized that the "development of learning environments and the development of theory were intertwined" (Bakker, 2018, p. 30). These mathematics education researchers imagined a possible future where students learned in ways that were more authentic to real-life experiences, and they envisioned—and brought about—new methods for studying teaching that supported this way of learning. In sum, DBR is future oriented with respect to both the ends of learning and means of supporting it.

DBR Builds Theory and Knowledge about Learning *and* Design

A design study is always engaged in building knowledge and theory about both learning and design. That is to say, the products of design are not the only thing that matters in DBR. The interventions are intended to embody theory and help understand the relations among theory, designs, and practice (DBR Collective, 2003; Sandoval, 2014).

Pinkard, Erete, Martin, and McKinney de Royston's (2017) study of narrative-driven curriculum in the Digital Youth Divas (DYD) project illustrates these intertwined priorities. Drawing on Nasir and Cooks's (2009) notion of identity resources, they sought to create a program that could support Black and Brown middle school girls' STEM interests and identities by developing new ideas about valued learning goals (ideational resources), new connections with peers and mentors (relational resources), and curriculum (material resources). The team designed a project-based curriculum anchored to an interactive virtual program whose narrative mirrored real life in middle school and integrated authentic STEM tasks into the episodes of the story line. Featuring virtual mentors with realistic intersectional identities, the curriculum allowed girls to immerse in the story virtually and then contribute in concrete ways to solving problems in the real world, with their real-life mentors (for instance, building a circuit board like the one that would be needed to light a LED bouquet of flowers in the episode).

Testing this conjecture allowed the team to continue to refine ideas about how different identity resources could support learning. They found that authentic, interactive narratives were motivating to girls, and that the curriculum offered material, relational, and ideational resources that supported the girls' identity development in STEM and computer science; the study also helped team members learn how to improve their design. For example, co-design of the narrative became an important part of the design. Team members believed that, to be relevant, the story needed to include input from the girls they hoped would benefit from it. After co-designing narratives with the girls, they found that this turned out to be the case, with the girls giving invaluable feedback about how to refine situations and characters to make them more relatable.

DBR Is Intended to Be Useful

Usability is both a motivation for and a crosscutting feature of DBR. In DBR, both the theories that guide design and the products need to be practical. To be of use in DBR, theories must do real "design work in generating, selecting and validating design alternatives at the level at which they are consequential" (diSessa & Cobb, 2004, p. 77). In this connection, the kind of theories that are useful tend to be *small* or *humble* (Cobb et al., 2003) in nature, focused on a specific domain of learning and development (e.g., how to support elementary-aged students' statistical reasoning; Cobb, McClain, & Gravemeijer, 2003), rather than *grand* theories that provide

mainly general frameworks or guidance for design (e.g., the idea of *scaffolding* to support learning in the ZPD).

Theory can inform efforts to create designs that are usable in a wide range of contexts as well. For example, Ahn and colleagues (Ahn, Campos, Hays, & DiGiacomo, 2019) used ideas from human–computer interaction research to inform their efforts to design and test a learning analytics dashboard that instructional coaches could use to support the improvement of mathematics teaching. The theories they drew on helped them make explicit to their partners design rationales for work, but also supported productive adaptations and uses of the dashboard for a variety of users.

Ahn and colleagues' (2019) approach of involving end users or implementers in design is becoming more common, as more design researchers embrace the idea that participation is key to creating usable designs. Though participation in co-design is not always a part of DBR in education (e.g., Alvarez, 2012), design researchers often view at least some participation as essential to design itself. We return to this conversation during our discussion of considerations for design.

DBR Is Iterative

Iteration, that is, revising a design based on a study of its enactment, is essential to DBR (Anderson & Shattuck, 2012). It is through iteration and careful documentation of the iterative process that designs are improved, and knowledge and theory are refined. Design researchers use a variety of strategies for documenting and interpreting the process of iteration, from developing design narratives (e.g., Ahn et al., 2019) to analyzing design tensions (e.g., Tatar, 2007), to tracing shifts in conjectured relations between design features and learning interactions (e.g., Wilkerson, 2017). Each of these methods helps design researchers coordinate changes in designs with evidence gathered about how designs are taken up in practice. Iteration also provides a means to help test theories that emerge from testing designs in practice (Gravemeijer & Cobb, 2013).

Design researchers do not always write about their iterations, or sometimes write only about one phase of iteration in their published studies; still other design researchers trace the evolution of the intervention over multiple iterations. Iteration does not always serve the same purpose, or provide the same benefit, but it is an essential part of design. For example, for Gutiérrez and Jurow (2016), iteration centered on attending to emerging issues of equity, and partners and communities were meaningfully involved in the process of iteration, with researchers holding themselves accountable for the ways that they promoted more equitable relationships in the community (e.g., Gutiérrez & Jurow, 2016). For Tzou and colleagues (2019a), iteration focused on the participatory design process, and the relational components that helped transform traditional power dynamics and roles taken up in DBR partnerships.

Bang and colleagues (2016) described yet another form of iteration that can take place in DBR in the context of a search for axiological innovations in learning, that is, innovations in the ways people relate to one another and to other living beings in their environment. Initial efforts in this project on Indigenous science learning focused on crafting formal processes and agreements among researchers, community-based educators, and community members, as well as consultations with elders about the project (Bang, Medin, Washinawatok, & Chapman, 2010). Over time, to help support more transformative relations among those involved in the effort, the team developed activities to help facilitate relationship building:

> Increasingly we worked to develop design practices to surface and acknowledge our collective experiences and help us to work toward imagining new possible futures. For example we often engaged in "river of life" activities, which is a visual narrative method that supports collaborators in telling their stories, perspectives, and diverse expertises about the past, present, and future by creating a collective visual artifact, working toward unpacking the trajectories that made the present moment possible and helped to imagine future trajectories. (p. 35)

In addition to illustrating how the focus of iteration can center on relationships, this project highlights ways that iteration can take place within participatory or co-design processes.

Examples of DBR That Illustrate Its Crosscutting Features

In this section, we present two different examples of DBR that illustrate each of the crosscutting features named above. The examples were chosen to reflect two common contexts of DBR, schools and communities. The first is a line of DBR that we have conducted in the context of a long-term research practice partnership (Farrell, Penuel, Daniel, Steup, & Coburn, 2020). The second is an example of community-based DBR conducted in partnership with parents in schools.

Case 1: Preparing Teachers to Develop Five-Dimensional Science Assessments

The inquiryHub research–practice partnership, which began in 2007, is a collaboration between the Denver Public Schools and the University of Colorado Boulder, and includes a number of other partners that support its work. The primary work of the partnership is in STEM education. Since the partnership's inception, it has (1) created a technology platform for supporting science teachers to customize their instruction that has been in continuous use within the district since 2009 (Sumner & the Curriculum Customization Service Team, 2010); (2) developed routines and

formative assessments supporting middle school science teachers to use responsive pedagogies (Penuel et al., 2017); (3) developed software tools and processes supporting algebra teachers to identify and select high-quality mathematical tasks (Johnson, Severance, Penuel, & Leary, 2016); (4) developed a yearlong, project-based biology curriculum (Affolter et al., 2018) aligned with the Next Generation Science Standards (NGSS Lead States, 2013). The line of research described below focuses on supporting teachers in learning to design new science assessments that embody the vision for teaching and learning proposed in A Framework for K–12 Science Education (National Research Council [NRC], 2012).

Future-Oriented

The vision of the NRC framework calls for new forms of assessment that are uncommon in today's schools, that is, assessments that require students to apply knowledge of science and use science and engineering practices to solve problems and explain phenomena in the world (NRC, 2014). The vision is oriented toward an imagined future in which science and engineering can be resources or tools in service of community priorities and civic engagement (Penuel, 2016). Moreover, the call of assessments to connect to students' interests and identities in meaningful ways to promote equity invites teachers to consider how their classrooms are promoting agency and epistemic justice in classrooms that address ways in which students of color, girls and gender nonconforming students, emerging multilinguals, and students with disabilities historically have not been seen as *knowers* capable of doing science (Penuel & Watkins, 2019). The focus of this line of DBR—to prepare teachers to develop and use assessments that address all *five dimensions* (5D) of the NRC framework (core ideas, practices, crosscutting concept, interest, and identity)—is a means to bringing about a future with different kinds of assessments and relationships among students and between students and teachers in science classrooms.

Developing Theory and Knowledge

The high-level conjecture of this current iteration of the project posits that supporting teachers to design these 5D tasks using tools and feedback can shift teachers' visions for science teaching and improve the quality of tasks they develop. Supporting this conjecture is the theory and practice of evidence-centered design (Mislevy & Haertel, 2006), which proposes that a careful analysis of the domain of learning to be assessed, coupled with the use of specialized templates called *design patterns,* can support developers to create valid assessments. Evidence-centered design is typically an expert-driven process (i.e., by professional assessment developers); the research sought to investigate whether templates could support teachers with limited experience in designing assessments to create 5D tasks. A design study was undertaken in which a small sample of teachers received these templates with

instructions on how to use them independently, while another sample took part in a 2-day workshop where they created assessments under the guidance of researchers, using the same templates. The study showed that both groups could, in fact, use the templates, and the use of those templates supported higher-quality assessments aligned with the vision of the framework (Penuel et al., 2019). Thus, the findings helped extend the range of applicability of evidence-based design to teachers and built knowledge of the ways tools could support design.

Supports for Usability

So that it would usable by teachers, the design team made significant modifications to the standard, evidence-centered design process. The team created a nine-step protocol for 5D task design, as well as a range of smaller, lightweight tools to support each step in the design. These tools included simplified templates that scaffold how to build science and engineering practices into tasks, question frames to support the incorporation of crosscutting concepts into prompts, sample exit tickets, a task screener that includes a rubric with checklist items, and reflective questions designed to help evaluate the "5D-ness" of existing tasks.

Iteration within the Project

One finding that emerged from the first iteration of the PD workshops was that in addition to templates, teachers found the feedback researchers gave on their assessments to be particularly useful. The design team had intended the feedback to be primarily a vehicle to share key findings with teachers as to how their tasks were being evaluated for research purposes. But, teachers found the feedback to be constructive and useful in helping them better understand 5D science assessment design. Therefore, the team incorporated feedback as a formal aspect of the learning design into a subsequent iteration, attending more to the structure of the feedback.

Case 2: PRIMES Project

Our second example concerns a line of DBR focused on supporting parent engagement in mathematics. The PRIMES project, which stands for Parents Rediscovering and Interacting with Math and Engaging Schools, was funded by the National Science Foundation. The goal of the project, led by Stanford researchers Angela Booker and Shelley Goldman, was to increase parents' confidence with reform-based mathematics teaching and with engaging with their child's school. The PRIMES project resulted in a small number of research publications, as well as a number of parent resources, including parent workshops, a television special called *The Family Angle* that aired on a digital public television channel, and a parent guide.

Future-Oriented

In contrast to projects that seek to engage parents on the typical terms that schools impose (Jay, Rose, & Simmons, 2017), the design team in PRIMES began with the premise that parents themselves bring important resources to accomplish this task. The researchers assumed that parents already engaged in some forms of mathematics in their household, some with their children, and that these could form the basis for supporting their children in school-based mathematics (Goldman & Booker, 2009). Therefore, as part of the research, they set out to take note of these resources and practices using ethnographic methods and a participatory design process to develop additional tools and resources for parents to support their engagement.

A key aspect of their vision for the future was one in which parents' relationship to mathematics—including school mathematics—was *repaired*. Math shame and fear were common among the parents in their study and hindered advocating for their children's learning. If parents could begin to feel like they were *math people*, they would be able to better advocate for their children and would themselves feel more comfortable in math learning spaces. The focus on repair, moreover, illustrates how one of the key goals of DBR can be centered on changing relationships among and between people and disciplinary practices.

Developing Theory and Knowledge

There were two key aims of the project, one related to developing knowledge of conditions under which repair of parents' relationship to mathematics might be facilitated, and one on how to support parents' participation in design.

A key concept guiding the researchers' efforts to promote repair was the sense of *epistemic authority* in mathematics (Booker & Goldman, 2016, p. 231), which forms a basis for supporting parents' agency and advocacy for their children's learning. Epistemic authority here refers to a confidence in speaking up about what parents know from using mathematics in their everyday lives and claiming its relevance to school mathematics that their children will encounter. The researchers also sought to cultivate among parents "the understanding that school math success is dependent on many factors that involve parents, ones that are quite independent of their understanding of classroom math" (Goldman, 2006, p. 58). The team's work started with the initial premise that "we could displace parents' fears of math by naming our everyday math practices and letting them start building new confidences" (Booker & Goldman, 2016, p. 224). This also depended on changing conditions in schools where other adults (e.g., teachers, administrators) positioned parents as not having competence in mathematics and were therefore treated as less than expert in their children's learning. The DBR tested this premise through developing and iterating in a series of workshops (described below) and documenting in a selected case study parents' changing sense of epistemic authority and agency over successive iterations of the workshops.

Rather than seeking to make a product that could *scale*, the design team sought to engage parents as co-designers and to develop knowledge of potentially replicable processes for co-design. The assumption that parents could be equal partners in design came from the researchers' commitment to a *competence-based* view of parents (Goldman, 2006). With that, PRIMES included four teams in a design consortium coordinated by researchers from Stanford University, each composed of parents, educators, and researchers. Two teams were based in school districts, and two were based in community organizations. Based on their experience of participatory design with parents, the researchers concluded that " 'open-ended social innovations' are crucial to systemic repair and that scaling method rather than product is a challenge for which PDR is well matched" (Booker & Goldman, 2016, p. 233).

Supports for Usability

Over the course of the partnership, the PRIMES project produced a number of resources that parents helped design and that were offered to parents outside the project sphere. A total of nine different workshops were created and delivered to multiple groups not only in the San Francisco Bay Area, but also across the country. The workshops were made available to others, too, to guide them independently of the research group. The team produced a television program for a digital channel of the Public Broadcasting Service (PBS). And, the design team produced a booklet detailing strategies parents could use to approach the school around aspects of school math during the middle school years. This booklet included topics from expectations around homework, to decisions about when to take algebra, to how to approach teacher conferences, and how to turn everyday math problem-solving opportunities into family math engagements.

According to the project's final report to the National Science Foundation, the workshops reached a total of 168 parents in three different locations: the San Francisco Bay Area, New York City, and rural Michigan. The San Francisco Unified School District shared the parent resource with every one of its parent liaisons to schools. The report also indicated that the television special aired in 2002 to more than 60,000 people. A total of 14 PBS and other educational stations additionally aired the feed.

Iteration within the Project

In the initial workshops with parents, researchers retained their position as experts—inadvertently supported by parents themselves—resulting in a significant early failure. According to Booker and Goldman (2016), the initial "workshop, and the kind of math problem solving accomplished, felt a lot like school, and as such, it reproduced the systemic rift we were seeking to repair" (p. 227). To address this issue, the team decided it would be more effective to reposition the teacher as a learner, and to build the next workshop around an open-ended planter box building project. This iteration proved more effective in some ways—the debrief conversation

engaged parents more. But, the teacher still functioned as the owner of knowledge, and teachers struggled to position families' cultures and personal experiences as valuable. It was not until a parent, who was active as a partner in co-design, became a facilitator that the dynamic shifted, with the parent proposing different kinds of activities that involved a design activity where doing mathematics was required but was also in the background to a greater degree. Importantly, the failures from each of these workshop iterations supported the team so they could better understand the nature of the math rift. Ultimately, the team synthesized their learning into four design principles: sustained open dialogue, learner authority/positioning, collaborative data analysis, muting individual and cultural deficit.

What Should Design Researchers Consider When Planning and Carrying Out Studies?

While working through the sorts of difficulties and failures described in the examples above is a feature of DBR, some more serious critiques of DBR have emerged over the years (e.g., Shavelson et al., 2003), each of which has resulted in clarification of the underlying principles of the approach as well as advances within it. The different types of critiques could also be used as considerations for design researchers when planning and carrying out DBR.

Attending to Methodological Rigor

DBR has been subject to various methodological critiques, and design researchers should care about the methodological rigor of their studies. For us, two criticisms rise to the top. First, since design researchers conduct their *experiments* in complex settings with a multitude of uncontrolled variables, some have argued that it is difficult for design researchers to meet scientifically rigorous standards for making reliable and valid claims (Kelly, 2004; Shavelson et al., 2003). Second, since design studies can produce huge amounts of data, some have pointed out that design researchers can easily *cherry-pick* results (Brown, 1992; Derry et al., 2010).

Making scientifically rigorous claims in DBR is different from doing so in other interventionist or descriptive approaches to research, but it is not impossible. First, it is important to understand how DBR arguments differ from these other approaches. At the root of these differences is the fact that DBR is not a single or static methodology. Some approaches have what can be distinguished as a shared *argumentative grammar* (Kelly, 2004), such as experiments, where there are common understandings (a grammar) for evaluating studies based on whether threats to validity have been addressed adequately through random assignment. But, design researchers follow different argumentative grammars (Bell, 2004). They draw on a variety of both experimental and observational methods. Rather than beginning with a shared argumentative grammar then, DBR arguments lead with substantive

theoretical conjectures about how best to organize for different forms of learning (Sandoval, 2014). Underlying each of these conjectures is a set of values about what is most worth learning, which themselves may become objects of critique and argument (Penuel & Shepard, 2016).

Conjecture maps are tools for figuring out if the things we believe promote the forms of learning we are trying to support are actually doing so. In a conjecture map, design researchers articulate their ideas about how particular designs will support particular kinds of learning by starting with a high-level conjecture. Design researchers then think through what it would look like if learners were to take up designs as intended by considering how learners embody designs via their tools and materials, prescribed roles for teachers and learners in the setting, and discursive practices (Sandoval, 2014). How learners interact with designs mediates their learning processes. Considering what we might see in these observable interactions between learners and designs, as well as in the artifacts learners produce through these processes, helps us begin to imagine what might actually happen as they take up designs (and thus articulate evidence for design successes and failures). Finally, design researchers consider how these mediating processes are intended to produce desired learning outcomes. Using a tool like a conjecture map, or some other means for keeping track of our ideas and how we are testing them, to explain our ideas about how both mediating processes of learning and embodiment of designs contribute to the kinds of change we are trying to make through our interventions helps us do a better job of evaluating how our designs function, and how those functions support particular kinds of learning (Sandoval, 2014, p. 25).

Supporting the Agency of Participants in Research

As we've emphasized, one of the crosscutting features of DBR is an attention to usability. Many design researchers believe that to create useful designs, their methods must be at least in some way participatory or collaborative (e.g., Couso, 2016). Design researchers differ in the level of agency they support for participants in design, as well as in the form agency takes in the process (Ormel, Roblin, McKenney, Voogt, & Pieters, 2012). In some instances, the agency of participants can extend to the DBR process itself (Severance, Penuel, Sumner, & Leary, 2016). Factors such as time, interest, and what is at stake all shape what level of agency participants have in design; determining roles and agency in design is often an ongoing (re)negotiation within teams (Penuel, Coburn, & Gallagher, 2013).

A number of scholars have pointed specifically to the question of *Who designs?* (Booker & Goldman, 2016; Engeström, 2011; Philip, Bang, & Jackson, 2018). Raising this question challenges design teams to consider what stakeholder groups are at the table in DBR, from teachers to parents to students. It demands that teams raise questions about the racial composition of their teams, and their preparedness to design both for and with particular groups. And, when particular groups cannot be at the table during the design process, how their input might be solicited is

an important consideration, as is the creation of structures for *answerability* (Patel, 2015) to those groups.

When different groups are at the table in co-design, inevitably questions arise as to *participation for what?* (Ormel et al., 2012). There are multiple motivations for engaging in design, as reviewed above, and these can sometimes come into conflict. Leal (2007) highlights how the co-optation of participation by institutions like the World Bank have made *participation* a buzzword. Participation must be structured in such a way that attends to power differences involved in participation in design (O'Connor, Hanny, & Lewis, 2011), and to the ways that participation can simultaneously enable some forms of action (and actors' agency) while inhibiting other forms of action (and actors' agency) (Golob & Giles, 2013).

Promoting Socioecological and Racial Justice

Many design researchers have not and do not always do a good job of mapping positionality, race, and power, and how these factors impact design. Vakil, McKinney de Royston, Nasir, and Kirshner (2016) write that DBR, with its future orientation and concern with usable theory, "marks an important departure in the educational sciences toward investigations of cognition and learning that recognize the centrality of context" (p. 3), but that explicitly treating race and power in designs is currently lacking and is "critical for DBR to fulfill its potential to contribute towards equity and realize its potential as a democratizing methodology that can intervene in educational practice" (p. 4). Missing particularly are treatments of how "race and power mediate researcher-researched relationships within DBR projects" (p. 4). Khalil and Kier (2017) offer an emerging antiracist methodological approach for integrating critical race theory into DBR in education that presents one approach for better theorizing race and power in design. They propose three principles or pillars: attending to interest convergence, critiquing liberalism, and privileging counternarratives in DBR.

There is more than a single justice project, or even a single notion of justice. For example, Indigenous scholars remind us that repairing relations with living beings beyond the human is an important justice project (Bang et al., 2016; Tuck & Yang, 2018). Important justice projects being pursued by design researchers include decolonization (e.g., Tzou et al., 2019a), as well as abolition, that is, the effort to eliminate *carceral thinking*, which emphasizes policing and control over thriving and liberation, from our social institutions (Agid, 2018). As an aid to these projects, a lens of *critical historicity*, that is, attention to the history of relations among institutions, communities, and with the land, can be beneficial (Bang et al., 2016).

Toward a Critical Pragmatism in DBR

In this chapter, we have sought to represent DBR as an evolving, heterogeneous family of approaches with common features. At its root, all forms of DBR are

deeply pragmatic in their approaches to developing and testing interventions with the potential to promote more equitable outcomes for students. DBR teams seek to change or transform practice through organizing and supporting new forms of learning. Whether cast as a form of *use-inspired research* (Stokes, 1997) or as a means of supporting "expansive notions of learning and mediated praxis fundamental to a transformative education for students from nondominant communities" (Gutiérrez & Vossoughi, 2010, p. 101), pragmatism suffuses DBR.

As DBR turns increasingly to tackle questions of race, power, and politics (Esmonde & Booker, 2016), it is important to bring one aspect of Dewey's pragmatism to the fore: the idea that education should prepare young people for participation in a democratic society. What kind of democracy, though, should DBR help prepare young people to join? DBR always makes bets on claims that a certain form of learning will bring young people into a particular future (Penuel & O'Connor, 2010); we would be wise to remain conscious of what those futures should be.

Emerging developments within the field point to the need for a more *critical pragmatist* (Feinberg, 2015) stance, that is, one that attends to both history and power. A critical pragmatism is a pragmatism "with teeth" that engages with conflict and pluralism (Hildreth, 2009, p. 798) and with questions of race (Eldridge, 2004). In this connection, new developments toward social design experiments as a form of DBR that engages systems of power directly, and that embraces a critical-historical perspective on systems, strike us as a promising direction (Gutiérrez & Jurow, 2016).

Emerging developments also point toward the need to develop new strategies for structuring co-participation in the context of a profoundly inequitable society, to promote ideals of engagement within a multiracial democracy. Here, promising developments include those being explored within the Family Leadership Design Collaborative (2017), where teams of researchers, families, and communities have been exploring ways to structure participation to amplify the voices of those who rarely have decision-making power in conversations about how to improve education. Similarly, emerging models for community-based partnerships show promise for multidirectional mentoring models, where senior researchers, junior scholars, and community members can learn together in the context of change efforts (Ghiso, Campano, Scheab, Asaah, & Rusoja, 2019).

One of the strengths of DBR has been its power to evolve in response to critiques. The current directions of DBR suggest that its evolution continues in this way. For this reason, we are hopeful that DBR is here to stay and continues to develop as a promising approach for promoting equitable change and justice in schools and communities.

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