Developing the Area of Design-based Implementation Research

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This paper provides an overview of the background and purposes of our workshop on design-based implementation research. The paper is intended to orient participants to the need to develop a new area of research that is focused on how to address persistent challenges associated with potentially effective innovations in STEM. At the workshop, participants will hear about and discuss exemplars of design-based implementation research and identify capacities, resources, and infrastructures that are needed to support development of the area.

The Need for New Forms of Implementation Research in STEM Education

Improving STEM education is an enduring, but elusive, national policy goal. Despite a decades-long commitment to improving teaching and learning for all students (e.g., National Research Council, 2007; President's Committee of Advisors on Science and Technology Panel on Educational Technology, 1997; The National Commission on Excellence in Education, 1983), the United States' educational system has made limited progress in improving science and mathematics achievement and in addressing persistent achievement gaps in students' preparation for college (National Center for Education Statistics, 2006, 2007, 2009). The recent report on K-12 STEM education issued by the President's Council of Advisors on Science and Technology (2010) makes a strong case for investing (at a level of $1 billion annually) in improvement efforts at scale. The need is to bring innovations and reform strategies that have been successful in a few settings to many, to make progress nationwide to improve STEM education.

In a recent analysis of the history of reform in science education, Pea and Collins (2008) point to the emergence of a systemic understanding of how to improve learning opportunities for all children. The hallmarks of this systemic approach, they argue, are an appreciation of the importance of connections among standards, curriculum materials, learning activities, classroom-based and summative assessments, teacher development practices, and educational leadership. Increasingly, there is also attention within this approach to the importance of organizational learning processes (Spillane, Gomez, & Mesler, 2009) and to the role that informal science education institutions and opportunities can play within and across the learning ecologies of individual learners and their communities (National Research Council, 2009).

Despite our growing understanding of the components required to realize a more coherent, equitable system of opportunities for STEM education, as a field we face significant institutional and conceptual challenges that impede change. First, our system of education maintains sharp divisions of labor among policy makers, publishers, and researchers who develop innovations and educational leaders and teachers who must implement them. This division of labor creates structural "principal-agent" dilemmas, where paradoxically agents who have problems are asked to solve them, using solutions advanced by principals (Cohen, Moffitt, & Goldin, 2007). Conceptually, this leads us to define the problem of achieving systemic change primarily as a problem of how to scale up effective interventions, with little consideration of other, more collaborative approaches to improvement (Mehan, Datnow, & Hubbard, 2010).

Within the educational research community, only a few research teams are organized in ways that address the challenge of systemic improvement, and these teams are relatively isolated from one another. In medicine, where research on translation of research findings into practice is a major focus, translational research teams include not only basic scientists but also medical practitioners, policy researchers, and organizational researchers (Woolf, 2008). By contrast, most teams in educational research include a more limited range of expertise, in part because of strong preferences for disciplinary specialization in the preparation of researchers and among university faculties (Eisenhart & DeHaan, 2005; Raudenbush, 2005). As a consequence, researchers (such as learning scientists) who design innovations do not have access on their teams to expertise in relevant theories of organizations and institutions that could help them explore best how actors in different settings will have to adapt innovations as part of enacting them. Likewise, policy researchers who study policy and program implementation do not have access to the methods for organizing participatory, iterative design processes familiar to learning scientists, methods that could help them advise policy makers on crafting policy documents that could help develop shared understandings between principals and agents (e.g., Tabak, 2006).

Finally, the infrastructure for improving education through systemic change initiatives limits possibilities for accomplishing longer-term institutional change. Research-practice partnerships form and end primarily in concert with short-term funding of grants and program initiatives at foundations and government agencies. As a result, the infrastructure for collaboration must be re-created from scratch at the outset of each new project (Donovan, Wigdor, & Snow, 2003). Further, funding streams are largely distinct for research to develop interventions and change strategies, for technical assistance to district and schools, for formal and informal institutions, and for program implementation. The separation of these streams helps to reproduce the divisions of labor described above that limit our ability to effect a transformation of STEM education.

Cultivating a Research Network for an Emerging Area of STEM Research

In this workshop, we aim to cultivate the development of capacities, resources, and infrastructures for research that aims to make STEM learning ecologies more coherent and robust for all learners. We define this kind of research as **design-based implementation research.** We use the term "design-based" to indicate that researchers are engaged simultaneously, iteratively, and collaboratively with practitioners in designing and studying systemic change efforts (Kelly, 2003). We use the term "implementation research," because in the sister disciplines of medicine and public health, this form of research has a robust infrastructure and a clear focus on the interdisciplinary challenge of bringing about large-scale improvements to complex systems (Fixsen, Naoom, Blase, & Friedman, 2005). Other names for this area of research include improvement research (Bryk, 2009), formative interventions (Engeström, 2008), and social design experiments (Gutiérrez & Vossoughi, 2010). We view these as a family of related approaches, and we anticipate that the area includes researchers who do not use any of these names to describe their research. At the same time, what distinguishes the multidisciplinary group we are assembling at the workshop from other research and development teams are that the researchers:

1. Adopt an intentional stance with respect to anticipating and addressing recurring problems of systemic change at multiple levels and settings.
2. Pay attention both to theories of learning and theories of implementation or change.

3. Attempt to prefigure new relationships between research and practice through how they organize their research efforts.

Adopting an intentional stance to addressing cross-level and cross-setting problems of systemic change. As many researchers do, the participants in this workshop share an *intentional stance* toward the activity of improving STEM education. By intentional stance, we mean that participants aim not only to describe but also to improve educational practices and conduct programs of research, partnership and policy to advance their aims (Pea, 2010). What distinguishes the participants from many other researchers is their explicit concern with improving implementation supports, tools, and social learning processes across levels of educational systems (e.g., designing school-level supports to accompany a classroom-level interventions) and, in some cases, across settings (e.g., school and after-school). In this respect, researchers' approaches to improvement are consistent with a complex systems view of education (Lemke & Sabelli, 2008) and with the idea of learning as taking place within a broad ecology of institutions and organizations across time and space (Barron, 2010).

Workshop participants enact this intentional stance through different means. In carrying out their research, some participants apply the engineering-oriented, design-based approach of the learning sciences to problems of implementation, developing and testing organizational and institutional supports for enacting ambitious instructional reforms (e.g., Cobb & Smith, 2008). Others' research focuses on developing accounts of the dynamics of policy implementation, with the aim of informing program and policy design (e.g., Maroulis, et al., 2010). Still others enact their intentional stance by forming enduring partnerships with school districts and conducting efficacy trials of interventions that target important problems of practice identified by district officials (e.g., Donovan, 2010).

Paying attention to theories of learning and theories of implementation or change. Models for improving teaching and learning in science and mathematics that have proven successful at scale share a dual attention to theories of learning and theories of the change process that actors in systems must undertake to realize the learning potential of an innovation (Confrey, Lemke, Marshall, & Sabelli, 2002). In their theories of learning, researchers specify clearly how interactions among the teacher, students, and curriculum materials can improve subject matter learning. In their theories of implementation and systemic change, researchers specify the systems change that is required to implement curricular and instructional supports effectively. Such theories can yield interventions that are "well developed" (Cohen & Ball, 1999), in that designers have articulated a fully fleshed out vision of all that is needed to support implementation and realized that vision in specific professional development plans, teacher guides, and, as necessary, instructions to principals and district leaders.

The theories that workshop participants bring are diverse, reflecting their different disciplinary orientations. Learning scientists associated with the Learning in Informal and Formal Environments (LIFE) Center, for example, bring ecological, social-semiotic, and actor-network theories to bear on the design of after-school and school learning environments (Barron, 2010; Vye, Bell, Tzou, & Bransford, 2010). Policy researchers and sociologists of education who will attend bring institutional, social capital, and social movement theories to analyzing implementation (Coburn, 2006; Frank, Zhao, & Borman, 2004; Spillane & Burch, 2006) and to studying strategies for bridging research-practice divides (Rosen, 2010). Cultural-historical activity and distributed leadership theories both consider implementation effectiveness as presenting "learning problems" for system actors that require collaborative design and

coordination to enact organization-level solutions to problems of practice (Cole & Engeström, 2006; Ikemoto & Honig, 2010; Resnick & Spillane, 2006; Spillane, et al., 2009).

Prefiguring new relationships between research and practice. There is no shortage of researchers, publishers, and other commercial providers offering innovations to schools, built around the promise of improving teaching and learning. These different providers, however, do not always share the same goals, and the institutional ecology within which they operate is constantly changing (Rowan, 2002; Spillane, 2006). The result is a system of education that is incoherent with respect to goals, that exposes students to instruction of varying levels of quality, and that preserves through its division of labor a wide gulf between the worlds of research and practice (Coburn & Stein, 2010; Kaufman & Stein, 2010; McLaughlin & Talbert, 2001).

In their work, workshop participants are engaged in different strategies that seek to change the relationship between research and practice, to create a tighter coupling between the two. Some are focused on creating lasting infrastructures that link educational institutions to networks of researchers and that focus on instructional improvement (Bryk & Gomez, 2008; Donovan & Pellegrino, 2003). Others are engaged in design partnerships with teachers, to develop curricular innovations (e.g., Penuel, Roschelle, & Shechtman, 2007), to improve professional development (e.g., D'Amico, 2010; Fishman, Marx, Best, & Tal, 2003), or to support the work of teacher learning communities (e.g., Horn & Little, 2010). Some see their efforts as contributing to a wider social movement that aims to change the dominant patterns of organization of the worlds of research and practice; as such, the forms of participation created within them serve to *prefigure* transformed infrastructure and motivate and sustain commitment to the cause of change (Brienes, 1982; Gamson, 1991). At a minimum, these efforts prepare different teams of researchers for new forms of collaboration and knowledge development required to develop the area of design-based implementation research.

What We Hope to Accomplish at the Workshop and Beyond

The workshop will present participants with opportunities to learn about and discuss examples of research focused on creating a more coherent, equitable system of opportunities for STEM learning and to identify *models of collaborative research* that can guide us toward addressing the broad challenge of improving implementation of ambitious teaching and learning opportunities in STEM education. We will bring together funders and scholars from a variety of disciplines inside and outside education who focus on improving learning in a range of formal and informal environments to engage in this discussion. We recognize that although many of the participants may know one another and be familiar with one another's research, a critical challenge will be to develop some anchors that can guide future work together.

To facilitate the development of these anchors, we will organize presentations and discussions around three worked examples, that is, research programs or projects that share the goal of the workshop and reflect the three characteristics described above. Worked examples or exemplars can be powerful tools to the development of "normal science" within disciplines (Kuhn, 1962). In our case, we aim not to produce a new discipline or disciplinary specialization, but rather a network that can build a new *thematically defined area of research* (Gee, 2010) that brings to bear multiple disciplinary perspectives on improving implementation effectiveness and that can be used to inform policy on achieving improvements to STEM education at scale.

Because any new thematically defined area of research needs outlets for publication, we also plan to publish a book of papers that include the worked examples from the conference, as well

as several other examples. These will be published as part of the National Society for the Study of Education (NSSE) Yearbook series, now published by Teachers College Record. Although the presenters and panelists will be the primary authors of chapters for the Yearbook, we invite other participants to consider contributing to it or to a special issue proposal to a journal.

Because this workshop is co-funded through the LIFE Center, we will also invite collaboration to inform ongoing research in the Center on translation of learning sciences principles into practice. We have a modest amount of funding available for such consulting, but we also imagine this funding may seed research proposals and new collaborations that can help develop this new area of research.

References

Barron, B. (2010). Conceptualizing and tracing learning pathways over time and setting. In W. R. Penuel & K. O'Connor (Eds). *Learning research as a human science. National Society for the Study of Education Yearbook, 109*(1), 113-127.

Brienes, W. (1982). *Community and organization in the New Left*. South Hadley, MA: J. F. Bergin.

Bryk, A. S. (2009, April). Support a science of performance improvement. *Phi Delta Kappan*, 597-600.

Bryk, A. S., & Gomez, L. M. (2008). Reinventing a research and development capacity. In F. M. Hess (Ed.), *The future of educational entrepreneurship: Possibilities for school reform* (pp. 181-187). Cambridge, MA: Harvard Educational Press.

Cobb, P., & Smith, T. (2008). District development as a means of improving mathematics teaching and learning at scale. In K. Krainer & T. Wood (Eds.), *International handbook of mathematics teacher education: Volume 3. Participants in mathematics teacher education: Individuals, teams, communities and networks* (pp. 231-254). Rotterdam, The Netherlands: Sense Publishers.

Coburn, C. E. (2006). Framing the problem of reading instruction: Using frame analysis to uncover the microprocesses of policy implementation. *American Educational Research Journal, 43*(3), 343-379.

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

Cohen, D. K., & Ball, D. L. (1999). *Instruction, capacity, and improvement*. Philadelphia, PA: Consortium for Policy Research in Education, University of Pennsylvania.

Cohen, D. K., Moffitt, S. L., & Goldin, S. (2007). Policy and practice: The dilemma. *American Journal of Education, 113*(4), 515-548.

Cole, M., & Engeström, Y. (2006). Cultural-historical approaches to designing for development. In J. Valsiner & A. Rosa (Eds.), *The Cambridge handbook on sociocultural psychology* (pp. 484-507). New York: Cambridge University Press.

Confrey, J., Lemke, J. L., Marshall, J., & Sabelli, N. (2002). *A final report on a conference on models of implementation research within science and mathematics instruction in urban schools*. Austin, TX: University of Texas, Systemic Research Collaborative for Education in Mathematics, Science, and Technology.

D'Amico, L. (2010). The Center for Learning Technologies in Urban Schools: Evolving relationships in design-based research. In C. E. Coburn & M. K. Stein (Eds.), *Research and practice in education: Building alliances, bridging the divide* (pp. 37-53). Lanham, MD: Rowan & Littlefield.

Donovan, S. (2010, May). *Use-inspired research and development: Addressing middle school challenges in the SERP-Boston field site.* Paper presented at the Annual Meeting of the American Educational Research Association, Denver, CO.

Donovan, S., & Pellegrino, J. W. (2003). *Learning and instruction: A SERP research agenda*. Washington, DC: National Research Council.

Donovan, S., Wigdor, A. K., & Snow, C. E. (2003). *Strategic education research partnership*. Washington, DC: National Research Council.

Eisenhart, M., & DeHaan, R. L. (2005). Doctoral preparation of scientifically based education researchers. *Educational Researcher, 34*(4), 3-13.

Engeström, Y. (2008). From design experiments to formative interventions. In P. A. Kirschner, F. Prins, V. Jonker & G. Kanselaar (Eds.), *Proceedings of the 8th International Conference of the Learning Sciences* (Vol. 1, pp. 3-24). Utrecht, the Netherlands: Erlbaum.

Fishman, B. J., Marx, R. W., Best, S., & Tal, R. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education, 19*(6), 643-658.
Fixsen, D. L., Naoom, S. F., Blase, K. A., & Friedman, R. M. (2005). *Implementation research: A synthesis of the literature*. Tampa, FL: Louis de la Parte Florida Mental Health Institute, National Implementation Research Network, University of South Florida.
Frank, K. A., Zhao, Y., & Borman, K. (2004). Social capital and the diffusion of innovations within organizations: Application to the implementation of computer technology in schools. *Sociology of Education, 77*(2), 148-171.
Gamson, W. A. (1991). Commitment and agency in social movements. *Sociological Forum, 6*(1), 27-50.
Gee, J. P. (2010). *New digital media and learning as an emerging area and "worked examples" as one way forward*. Cambridge, MA: MIT Press.
Gutiérrez, K., & Vossoughi, S. (2010). Lifting off the ground to return anew: Mediated praxis, transformative learning, and social design experiments. *Journal of Teacher Education, 61*(1-2), 100-117.
Horn, I. S., & Little, J. W. (2010). Attending to problems of practice: Routines and resources for professional learning in teachers' workplace interactions. *American Educational Research Journal, 47*(1), 181-217.
Ikemoto, G. S., & Honig, M. I. (2010). Tools to deepen practitioners' engagement with research: The case of the Institute for Learning. In C. E. Coburn & M. I. Honig (Eds.), *Research and practice in education: Building alliances, bridging the divide* (pp. 93-108). Lanham, MD: Rowman & Littlefield.
Kaufman, J. H., & Stein, M. K. (2010). Teacher learning opportunities in a shifting policy environment for instruction. *Educational Policy, 24*(4), 563-601.
Kelly, A. E. (2003). Research as design. *Educational Researcher, 32*(1), 3-4.
Kuhn, T. S. (1962). *The structure of scientific revolutions*. Chicago, IL: University of Chicago Press.
Lemke, J. L., & Sabelli, N. (2008). Complex systems and educational change: Towards a new research agenda. *Educational Philosophy and Theory 40*(1), 118-129.
Maroulis, S., Guimerà, R., Petry, H., Stringer, M. J., Gomez, L. M., Amaral, L. A. N., et al. (2010). Complex systems view of educational policy research. *Science, 330*(6000), 38-39.
McLaughlin, M. W., & Talbert, J. E. (2001). *Professional communities and the work of high school teaching*. Chicago, IL: University of Chicago Press.
Mehan, H., Datnow, A., & Hubbard, L. (2010). A co-construction perspective on organizational change and educational reform. In W. R. Penuel & K. O'Connor (Eds). *Learning research as a human science. National Society for the Study of Education Yearbook, 109*(1), 98-112.
National Center for Education Statistics (2006). *The Nation's Report Card: Science 2005*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.
National Center for Education Statistics (2007). *America's high school graduates: Results from the 2005 NAEP high school transcript study*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.
National Center for Education Statistics (2009). *The Nation's Report Card: Long-term trend 2008*. Washington, DC: Institute of Education Sciences, U.S. Department of Education.
National Research Council (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: National Academies Press.
National Research Council (2009). *Learning science in informal environments: People, places, and pursuits*. Washington, DC: National Academies Press.
Pea, R. D. (2010, October). *Augmenting educational designs with social learning.* Paper presented at the Principal Investigators Meeting of the National Science Foundation's Science of Learning Centers, Arlington, VA.
Pea, R. D., & Collins, A. (2008). Learning how to do science education: Four waves of reform. In Y. Kali, M. C. Linn & J. E. Roseman (Eds.), *Designing coherent science education* (Vol. 3-12). New York: Teachers College Press.
Penuel, W. R., Roschelle, J., & Shechtman, N. (2007). The WHIRL co-design process: Participant experiences. *Research and Practice in Technology Enhanced Learning, 2*(1), 51-74.
President's Committee of Advisors on Science and Technology Panel on Educational Technology (1997). *Report to the President on the use of technology to strengthen K-12 education in the U.S.* Washington, DC: Author.
President's Council of Advisors on Science and Technology (2010). *Prepare and inspire: K-12 education in science, technology, engineering and math (STEM) for America's future*. Washington, DC: Executive Office of the President.
Raudenbush, S. W. (2005). Learning from attempts to improve schooling: The contribution of methodological diversity. *Educational Researcher, 34*(5), 25-31.

Resnick, L. B., & Spillane, J. P. (2006). From individual learning to organizational designs for learning. In L. Verschaffel, F. Dochy, M. Boekaerts & S. Vosinadou (Eds.), *Instructional psychology: Past, present and future trends. Sixteen essays in honor of Erik de Corte.* (pp. 257-274). Oxford: Pergamon.

Rosen, L. (2010). Examining a novel partnership for educational innovation: Promises and complexities of cross-institutional collaboration. In C. E. Coburn & M. K. Stein (Eds.), *Research and practice in education: Building alliances, bridging the divide* (pp. 55-72). Lanham, MD: Rowman & Littlefield.

Rowan, B. (2002). The ecology of school improvement: Notes on the school improvement industry in the United States. *Journal of Educational Change, 3*(3-4), 283-314.

Spillane, J. P. (2006, July). *Getting to organizations and systems without losing touch with learners and teachers.* Paper presented at the 7th International Conference of the Learning Sciences, Bloomington, IN.

Spillane, J. P., & Burch, P. (2006). The institutional environment and instructional practice: Changing patterns of guidance and control in public education. In H.-D. Meyer & B. Rowan (Eds.), *The new institutionalism in education* (pp. 87-102). Albany: State University of New York Press.

Spillane, J. P., Gomez, L. M., & Mesler, L. (2009). Notes on reframing the role of organizations in policy implementation. In G. Sykes, B. Schneider & D. N. Plank (Eds.), *Handbook of education policy research* (pp. 409-425). Washington, DC: American Educational Research Association.

Tabak, I. (2006). Prospects for change at the nexus of policy and design. *Educational Reserchер*, 24-30.

The National Commission on Excellence in Education (1983). *A nation at risk: The imperative for educational reform*. Washington, DC: U.S. Department of Education.

Vye, N., Bell, P., Tzou, C. T., & Bransford, J. D. (2010, March). *Instructional design principles for blending and bridging science learning across formal and informal environments.* Paper presented at the National Association for Research in Science Teaching Annual International Conference, Philadelphia, PA.

Woolf, S. H. (2008). The meaning of translational research and why it matters. *The Journal of the American Medical Association, 299*(2), 211-213.

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