

Reconceptualizing the Goals and Process of Educational Research Funding: Interconnecting Scholarship and Practice

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Introduction

In this article the authors reflect on their learning while Senior Program Officers in the Directorate for Education and Human Resources of the National Science Foundation, where they have directed a number of grant programs that fund peer-reviewed educational research in science, mathematics, and technology. Our collective experience includes research into instruction and policy, learning and intelligent systems, applications of advanced technologies, and networking infrastructures in education. This article is not a synthesis of the extensive prior literature on the need to link scholarship to practice, but instead an invitation for dialogue about “the awful reputation of education research” (Kaestle, 1993; 1997) from a perspective informed by policy and funding experience. We argue for a new prioritization of research funding initiatives, highlighting crucial types of educational studies currently undersupported.

Our approach for increasing the impact of research funding on education is based on reconceptualizing the relationship between scholarship and practice in the context of an urgent need for sustainable, scaleable, high quality educational innovation directed towards all students. Central to our funding strategy for interweaving educational research and practice is recognizing that:

- (a) Educational reform is an iterative process of continuous improvement requiring long-term research investments that evolve in their nature.
- (b) Parallel to other research situations, scholarly contributions to educational improvement must involve an ongoing interplay between theory and experiment.
- (c) If the education system is to change, the role of practitioners in the processes of experimentation and adaptation must become paramount.
- (d) Sustainable improvement depends on transferring the ownership of innovation from the scholarly community to practitioners and policy makers in the evolving educational system.

Even when most supportive of practitioners, in the past educational research funding has not focused sufficient attention on the limits of scholarship as sole mechanism for institutionalizing the processes of innovation.

The first two sections that follow summarize how researchers currently attempt to shape practice, then describe mutually developed implementation studies as an alternative innovation strategy with greater impact. The next two sections depict how educational practitioners currently view the role of research in the process of innovation, then delineate alternative policies that could improve the utilization of scholarship in applied settings. Our discussion focuses on what is missing from current funding approaches for research directed at enhancing educational

practice—*not* for all aspects of research.

The Research Context

Historically, the relationship between researchers and practitioners has taken various forms, some quite close and supportive (Kennedy, 1997; Wagner, 1997). However, with few exceptions, researchers' strategies for inducing change in educational practice have emphasized the transfer to teaching or to policy making of results and insights conceptualized by the scholarly community. Funded projects have been driven mainly by goals of contributing to the accumulation of scholarly knowledge; disseminating this knowledge to practitioners as materials, directives, or rules has been seen as an uncoordinated responsibility of the investigators. This investment strategy does not foster analyses of synergy and of comparative quality. To enable more scaleable and sustainable research innovations, we suggest reprioritizing funding strategies to highlight innovative types of studies that empower the improvement of practice in pervasive ways.

The most common funding strategies for research-based educational improvement have several limitations:

1. Because in general funders allocate resources via disconnected, relatively small awards, research insights about the educational system are often limited to isolated, minor findings about individual practice and collective policy, leading to outcomes that miss crucial systemic relationships and don't reinforce links among various components of schooling.
2. In funding program guidelines, learning frequently is assumed to occur only in classroom settings (based on curriculum, guided by teachers, managed by schooling organizations), rather than as a process distributed across all of everyday life and shaped by interactions with families, employers, and communities. This again leads to a narrow, disconnected perspective about educational innovation.
3. Scholarly peer-reviewed decision making about funding awards often focuses on research-driven issues peripheral to the concerns of practitioners and policy makers, or emphasizes studies of highly restricted situations from which results do not generalize to other contexts. . Since "all education practice is local," highly restricted studies are important, but do not build theories or test general hypotheses. They are design experiments whose reproducibility is unclear and therefore are (appropriately) seen by the general audience as of limited value.
4. The dissemination requirements of funding programs frequently do not obligate researchers to report their outcomes in ways that stress the types of evidence that educational implementers and the public find persuasive. As a result, practitioners seldom develop a deep understanding of a research innovation's goals, conceptual framework, implementation process, and

evaluation strategy.

Because of these and related problems, insights from current research may provide valid new ideas for improvement in practice, but seldom make a general and sustainable impact on the field or accumulate into well understood, coherent strategies for implementing multiple innovations simultaneously.

Even when research is conducted by practitioners, the use of “classical” investigative strategies vitiates the impact of their findings. For example, usually teachers’ “action research” on their classrooms is shaped by a research-centric perspective on education as composed of independent classroom units in which teaching and learning can be improved in major ways through reflective analysis at the ‘micro’ level. This intrinsically limited approach is mirrored by parallel misconceptions about a separate policy making sphere in which research on aggregated patterns and trends provides all the data needed for decision making. Funding programs geared to practitioner or policy maker research too often replicate this “micro-practice/aggregate-policy” disconnected model of educational intervention and therefore achieve little lasting impact.

Despite these problems, funded research has led to many valid, useful models of pedagogy (Darling-Hammond, 1997; Dede, 1998; National Commission on Teaching and America’s Future, 1996), to policy commitments in support of research linked to educational improvement (President’s Committee of Advisors in Science and Technology, 1997), and to advances in our understanding of how people learn (Bransford, Brown and Cocking, 1999; Donovan, Bransford and Pellegrino, 1999). Collectively, however, insights from many exciting programs and projects have not resulted in pervasive, widely accepted, sustainable improvements in actual classroom practice; in a critical mass of effective models for educational improvement; or in supportive interplay among researchers, schools, families, employers, and communities. Even when education research deals with the right issues, too often its results remain invisible outside of the scholarly community. The root causes of this shortfall rest partially with scholars themselves, partially with the agencies that fund educational research, partially with the distributed, loosely coupled nature of the educational system, and partially with a “quick fix with a silver bullet” mindset in our culture. Also, because policy makers are slow to take into account fundamental changes taking place in the context of educational practice, their actions often erroneously assume a dormant societal and educational environment.

Integrating current research on important pieces of the educational puzzle into next-generation, overarching models of innovation is a task that calls for different funding scales and mechanisms than typical today. Even when projects strive for greater descriptive understanding of educational and societal dynamics, their emphasis is generally on laboratory or design experiment studies that create atypical “islands of innovation.” Only sizable implementation “testbeds” that

deal with scalability, generalizability, local adaptation, and sustainability can advance these ideas for improvement to the next level. However, despite the fact that practitioners and policy makers are focused on exactly these issues, funding for such testbeds is currently only a small fraction of the total research portfolio.

As studies of the processes underlying educational change document (Cuban, 1990; Fullan, 1993), systemic relationships are crucial determinants of whether the implementation of a strategy for improvement succeeds or fails in reaching its educational—as opposed to educational research—objectives. In addition, a lack of systemic analytical frameworks makes it difficult for researchers and practitioners to develop insights on how attempts at innovation interact. Also, seldom are research methodologies in use by other scholarly fields brought to bear on educational systems, even though these analytic methods have contributed to the understanding of designed, human contexts (e.g., cities, corporations) and of institutions charged with rapid technology-based improvement (e.g., hospitals). Such theory-based organizational and system-wide frameworks are needed in order to identify understudied pressure points where new ideas could lead to coherent strategies for educational improvement.

For lack of such a systemic perspective, the educational research portfolios of both NSF and the U.S. Department of Education have not permeated these agencies' implementation portfolios (materials development, teacher professional development, organizational reform). In part, this is because systemic issues have been explored almost exclusively in the limited context of *evaluating* systemic projects rather than deeper studies of systemic processes in testbed situations. This approach leaves undeveloped many opportunities for creating ongoing partnerships among educators, parents, employers, disciplinary experts, and communities, relationships that could lead to improvements in students' (and teachers') learning.

The common practice of conducting studies of large-scale educational interventions as “evaluations” does not create the deep research base needed. Evaluation methodologies and goals focus primarily on evidence of effectiveness; this often omits process issues and crucial variables outside the subsystem being studied. Also, such an approach removes the responsibility for practitioners and policy makers to be active participants in assessing implementation strategies and results. Too often, experiments and evaluations are imposed on schools in a way that does not foster reflective processes that could accumulate learning; we see funding for policy maker- and practitioner-centered processes of experimentation, assessment, and reflection as a crucial enabler of sustained improvement.

Mutually Developed Implementation Studies as a Better Funding Strategy

How could investigators and funders transcend these limitations in research funding and

conduct? Reconceptualizing research priorities and processes to focus more on implementation studies mutually developed by scholars, practitioners, and policy makers is a promising strategy to develop sustainable impacts on practice. This agenda can be seen as driven by an interactive view of the role of the target institution:

Institution's role	Program focus
<i>Passive Dissemination</i>	<i>Demonstrations and Models</i>
<i>Interactive Adaptation</i>	<i>Adaptation experiments Seeding Change</i>

We believe too little emphasis is placed on *research* funding for *in-situ* adapting, analyzing, and scaling-up interventions and policies that, as isolated islands of innovation, have been successful in some other educational context. Even less priority is given to modeling and generalizing the coherent processes that led these innovations to succeed in design experiment settings.

To achieve coherent, sustainable, and scaleable change, we posit that understanding the process of innovating (i.e., of altering standard practices) is as important as studying its outcomes. In the few instances when we have seen the evaluation of new strategies for change lead to deep understandings of sustainability as well as a plan of action, the “evaluation” (both formative and summative) was performed by the project team, led by a strong researcher. In this situation, the objective was not only to “evaluate” the performance of the project—a worthy goal—but also to model and institutionalize its gains. Such internal reflective learning could be part of all large-scale implementations, rather than limited to projects undertaken with a specific innovation research purpose or subsumed as a minor objective in an external evaluation of an implementation’s performance.

Certainly, this type of research on the sustainability and scaling-up of reforms is expensive, people-intensive, and time consuming; but these are not the only reasons why such studies are seldom done. Implementation (systemic, applied) research does not fit well within conventional scholarly academic career paths. These studies demand a multiplicity of theoretical and

methodological perspectives and require researchers to share control of the investigative process with practitioners and policy makers. When such close partnerships are in place, researchers must not only relinquish sole power over the analytic process, but also act as brokers to guide and mediate the reflective interactions of other stakeholders. This is a skill for which most investigators are not prepared—in part because conceptual frameworks for this type of research are not well developed, in part because this capability is best fostered through supporting changes in practice within integrated implementation and research “testbeds” (an uncommon experience for scholars).

As has been recently suggested by the President’s Committee of Advisors in Science and Technology (1997), if our ultimate goal is long-term, pervasive, quality educational improvement, we must find ways to invest a “critical mass” of funds and human resources in *clinical-type research*. This article argues for a definition of such research as reflective interplay between basic research and practice, a process that is bi-directional and helps both sides evolve towards increasingly sophisticated objectives.

Such a bi-directional process should not be construed as limiting funding to 'applied' research. The strategy we propose follows the arguments presented by Stokes (1999) on 'use-driven' fundamental research, that is, fundamental research on critical and fundamental issues of principled practice. The example given by Stokes is the close interplay of molecular and clinical research under NIH sponsorship. In discussing its relevance to learning research, we will use a term that is in contraposition to 'use-driven': 'curiosity-based' research. Using the word 'curiosity' helps to focus the comparison on the reasons behind the research questions posed. Curiosity-driven research questions arise from the theoretical and hypothetical dynamics of the research field, with priorities driven by the investigators' interests. The difference between use-driven and curiosity-driven research is not the 'basic' or 'applied' nature of the study; rather, it is the community of practice in which the research objectives are embedded and that first appropriates its results.

An example from research on learning may help clarify what we mean.² Take research on the linking of students' activities out of school to their learning in classrooms (use-driven), or the transfer of knowledge acquired via intuitive and implicit learning into formalized knowledge (curiosity-driven). Similar research questions are posed in different terms, and the answers would inform different types of application.(Bransford and Schwartz, 1999)

In use-driven, clinical research relationship among scholars and practitioners,

²The difference between cognitive science research and learning research lies at the center in NSF. ROLE received 180 preliminary proposals from a wide array of research communities submitted to NSF's education research programs in the past. In multiple cases, the pr

implementation is not dissemination: the expected acceptance of recipes and materials for innovation developed by others. Implementation is instead the reflective adaptation or recreation of a process that enabled a similar group to succeed in another educational setting. Focusing on the process as well as on outcomes enables practitioners to start with objectives consistent with their own current problems and worldview, then evolve towards increasingly more powerful goals as they reflectively adapt innovations. This type of interaction among scholars, policy makers, practitioners, and other stakeholders in quality education undercuts the limitations of conventional research discussed earlier and lies at the heart of effective, sustainable scaling-up through the mutual evolution of goals and outcomes.

The intent of the research endeavor shifts from achieving an expected outcome to planning for continual, reflective evolution. In our view, even the best of predetermined goals too often lead to implementations that call for either locally unattainable or unimportant outcomes, or worse, to the co-opting of the original goals. Evolving objectives, on the other hand, require developing a shared, long-term vision of what excellence in education means. Some central questions in this process of mutually conducted implementation research are what are the critical insights needed *here and now* to plan for and achieve an educational system's long-term goals? What is the existing knowledge base in a particular situation, and where are the pressure points in that context for augmenting that knowledge? What types of intermediaries can aid or subvert the institutionalization of an ongoing relationship between practice, policy making, and basic, applied, and systemic research?

Emerging information technologies offer intriguing ways of potentially creating virtual "knowledge networking" communities among researchers, practitioners, and policy makers. Three years ago, NSF instituted a new multidisciplinary funding program to examine the potential of emerging information technologies in fostering "Knowledge and Distributed Intelligence" (KDI). This initiative [<http://www.ehr.nsf.gov/kdi/default.htm>] was prompted by fundamental shifts that new interactive media are creating in the process of science. Scientists are moving away from an investigative process based on reading others' research results in journal publications as a means of informing and guiding one's own scholarship. Instead, scientists are engaged in virtual communities for creating, sharing, and mastering knowledge: exchanging real-time data, deliberating alternative interpretations of that information, using "groupware" tools to discuss the meaning of findings, and collectively evolving new conceptual frameworks.

NSF calls this process "knowledge networking" and is funding a series of KDI investigations to study these virtual communities both in the context of science and as a

ROLE questions differed from the ones they would have asked if submitting to a discipline program, but would contribute to their overall research plan.

generalizable process that could enhance many forms of reflective human activity. Through knowledge networking, an emergent intelligence appears in which the virtual community develops a communal memory and wisdom that surpasses the individual contributions of each participant. NSF is supporting studies of this process through its “Learning and Intelligent Systems” (LIS) initiative within KDI. Both knowledge networking and emergent intelligence are important new capabilities that could potentially transform implementation studies in education.

Knowledge networking involves creating a community of mind (Dede, 1999). Through sharing disparate data and diverse perspectives, a group develops an evolving understanding of a complex topic. Over time, the group’s conception of the issues continually expands and deepens, at times broadening the range of fields and experiences seen as relevant. During these times, the membership of a networking community grows to include participants who bring new perspectives and backgrounds. Thus, a network is in longitudinal flux as an ever-larger cast of members redefines how to conceptualize the topic; this involves a constant collective acculturation into new ways of thinking and knowing. For example, in the context of educational reform, the participants in a knowledge network might be teachers, administrators, parents, taxpayers, politicians, teacher trainers, researchers, school board members, and other policymakers—each bringing differing perspectives and knowledge across multiple educational settings. Communal learning is at the core of the networking process.

This collective learning mirrors the complex initial acculturation process that people who wish to join a knowledge networking community must undergo to become effective participants. This acculturation involves:

- mastering a common language and a generally accepted set of theories and mental models (to provide a framework for communication),
- inculcating communally defined processes of collecting and analyzing data (to enable sharing reliable information),
- developing proficiency in design, reasoning, and argumentation (to facilitate the evolution of ideas), and
- accepting a common set of values, such as respect for others’ perspectives (to encourage wide participation).

Currently, the absence of these types of acculturation undercuts opportunities for sustained educational reform. For example, the war between proponents of phonics and advocates of whole language illustrates the dysfunctional dynamics that can occur without mutual acculturation processes to enable reflective dialogue that can promote a discussion of *when, for which children,*

and under what circumstances is each pedagogy more appropriate. Through tools for representation, collaboration, and community building, new interactive media can create a framework within which constructive interaction can occur. Advances in information technology aid knowledge networking through providing rich sources of data, rapid information exchange, sophisticated analytic tools, and the collective intellectual capacity to tackle the complex problems that underlie educational innovation.

The new types of funding initiatives we advocate could create educational “testbeds” to explore networking design for a class of social knowledge communities that have properties different from those of virtual scientific research networks. Transfer of knowledge among members of such educational communities—in ways that enable them to adapt solutions to their own contexts—is not simply exchange of superficial information about successful innovations. It requires engagement in rich, artifact-focused dialogue that provides detail about the nature and processes of education reform. For example, educators can undertake collaborative annotation of video-based case studies of educational practice that include ancillary information such as student products and teacher reflections (Jacobs et al. 1997). Knowledge networking technologies represent a new and powerful strategy for enhancing innovation sharing and adaptation, since practitioners and policy makers find direct knowledge about each others’ practices much more convincing than conventional forms of research evidence.

Typically, when islands of innovation in education emerge, they do not scale-up or transfer and eventually wither away. Evolving small-scale innovations into widespread shifts in standard operating practices necessitates changes in organizational structures, individual beliefs and values, and community commitment. By building bridges from reflective innovation to standard practice, testbed knowledge networks provide an excellent venue for exploring scalability and sustainability in educational innovation. However, this requires reconceptualizing traditional funding strategies for linearly transferring innovations from research to practice. Instead, researchers become intermediaries among practitioners, and practitioners become co-developers of innovative models.

In this article, by identifying what we see as major gaps in current research studies, our focus is on defining a balanced portfolio of education research activities, itself embedded in a body of learning research. To a great degree, the need to revisit how research impacts practice is a reflection of a general paradigm shift in implementing innovations, focusing on ‘systems’ that resist or empower change (Senge, 1999). In recent federal funding programs (e.g., the Interagency Education Research Initiative, IERI, <http://www.nsf.gov/IERI>; and the Research On Learning and Education Program, ROLE, <http://www.nsf.gov/pubs/2000/nsf0017/nsf0017.html>, NSF 00-17), an important emerging emphasis is exploration of the educational system *qua*

system. Priority is given to projects that explore the crucial interplay between policy goals, research outcomes, and actual classroom changes.

We believe that a greater emphasis should be placed by the educational research community and its funding organizations on:

1. Developing generalizable conceptual frameworks that coherently advance knowledge in support of sustainable improvements in teaching, learning, cognition, motivation, and problem solving for all students.
2. Conducting large-scale interventions *as design experiments* (Collins, 1996, Brown, 1992) based on innovations with the potential of enabling all learners to master more complex content via sophisticated and adaptable pedagogies, often enhanced through technology.
3. Conducting a reflective ("taking stock") cross-intervention analysis of the implementation process itself, so that researchers, practitioners, parents, and policy makers can understand the process, modify it, and achieve more effective learning environments that serve the needs of all students.

These goals can be accomplished by a balanced portfolio of research studies, undertaken not linearly but in a richly intergenerative fashion, categorized by methodology and objectives as follows:

1. *basic research and small, focused laboratory-type experiments*: designed to advance foundational knowledge (for example, cognitive science research, some aspects of cognitive neuroscience and neural networks, studies of how naive learners and experts in a given area organize their learning, effects of cognitive tool use in stages of intellectual development, etc.)
2. *design experiments and applied research*: design experiments to advance the practices of teaching, learning, and organizational management (for example, longitudinal studies of the uses of scientific and mathematical modeling as pedagogy, environments that support learning of increasingly complex tasks, theories of instructional design in environments where learners have differing repertoires of learning styles, etc.)
3. *data gathering and analysis studies of prior and existing practice and of intervention experiments*: designed to evaluate and rationalize outcomes across laboratory and intervention studies (for example, surveys of teacher certification in the topic being taught, issues of gender and career choices, etc.)
4. *systemic research on reform consortia and on large-scale intervention experiments*: designed to advance the implementation of intervention experiments and research-based

innovations in large-scale and complex educational systems (research and implementation testbeds in specific contexts, studies of reform consortia, comparison of the economics of scaling-up models, role of motivation and intellectual ownership in sustaining reform, social and ethnographic studies, policy research, economic co-dependence of publishers, software developers, other vendors and schools, etc.)

In summary, we see the need for reflective and adaptive research methodologies applied to the study of complex educational systems by these systems themselves, in collaboration with researchers. But how do practitioners and policy makers currently view the role of research?

The Educational System Context

Traditionally, the primary goal of educational practitioners and policy makers has been to efficiently follow standard operating procedures, modifying these only when current learning outcomes fall dramatically short of society's needs and expectations. In the event that innovations are necessary to remediate shortfalls, the interventions attempted are seldom based on prior knowledge, on validated experience, or on research evidence; but instead often emerge from political expediency or currently popular strategies for change. Implementation projects seldom monitor relevant research and generally limit their goals to "fine-tuning" current approaches rather than searching for more ambitious visions. Too often, practitioners and policy makers reject as "impractical" a reflective, iterative approach to implementation, thereby undercutting the leverage research might provide in developing strategic objectives and effective evolutionary processes for improvement.

As discussed earlier, intervention experiments are one means to introduce alternative, reflective innovation strategies into a large complex context. However, in order to succeed, implementation research must be based on insights from design experiments and must focus on reflective adaptation to given contexts. Unfortunately, in practice this is not often the case; the balance between "general," "generalizable," and "localized" knowledge acquired from educational interventions is usually not clear or even present in reports on their effectiveness. In part, this is because the demand of practitioners and policy makers for immediate results washes out the development of general ideas or generalizes ideas too soon or rediscovers what is already known. Interventions mandated by local boards, politicians, or the public are typically not viewed as *applied* experiments that build on laboratory trials through iterative refinement to match a particular situation. Rather, they are seen as 'silver bullets' that will magically solve a pressing problem. The question too frequently asked (*what works*) is inferior to the perspective *how can we make what works, work for us?* Workable, sustainable solutions are not jumps from one stable state to another, but instead follow a self-correcting, at times meandering, path.

A variety of problems plague attempts by educators to initiate research-based implementation studies. Performers and audiences are often different for laboratory research and implementation studies; in the absence of common participants, building connections among these types of experiments is difficult. Organizations that contribute to educational inertia, such as standardized testing corporations and textbook companies, are seldom included in our models of change; yet involving these types of stakeholders in systemic innovation efforts is often vital to success. These and other disconnects among basic research, implementation studies, and policy making hamper aggregating the outcomes of experiments towards a larger goal and undercut the ownership of change in those who must implement innovations.

Since a compelling need exists for more clinical and implementation research, the educational community must undertake the task of capacity building for a new generation of applied researchers and research-informed practitioners. At present, most scholars know better how to perform laboratory analyses than how to conduct large-scale implementation studies as theory-building research (rather than evaluation). Most investigators do not have good mental and methodological models of intervention and systemic research, which are similar to applied scholarly activities in medicine and engineering where the relation between general knowledge and local and individual interventions is crucial. In the absence of sophisticated implementation strategies, practitioners and policy makers are skeptical of what they see as “ivory tower” remedies and often inadvertently eschew or co-opt the core of innovations in the process of adapting them. We need to fund the evolution of innovative, mutually evolved methodologies for this type of research.

In the fields of medicine and engineering, integrating new research insights into practice is appropriately seen as a professional goal mutually achieved by theoreticians and practitioners. Unfortunately, in education this evolution of practice is instead approached as an issue of control. For example, the expectations of the medical research community about the role of physicians are in sharp contrast to the views of educational researchers about teachers: Physicians are seen as partners in the improvement of public health, but teachers are too often viewed as impediments to implementing improvements in students’ learning. Terms such as “teacher enhancement” illustrate a perspective that views knowledge about educational practice as a one-way flow from experts and researchers to teachers. Absent a supportive relationship in which the educational research community acknowledges teachers and administrators as professionals with insights to offer, and educators’ institutions as learning organizations that shape the evolution of practice, those in the field have few inducements to incorporate and sustain research-based improvements that reshape standard operating procedures.

Lagemann (1997) analyzed the history of educational research from the very useful

perspective of how the professionalization of this field has influenced linking knowledge and action in education. As a complementary perspective, limits on the professionalization of practitioners in U.S. education (i.e., not supporting the development of their capacity for independent judgment and knowledge of their subject matter and its pedagogy, not providing time for their reflection and sharing ideas with colleagues) hamper linking knowledge and action. Comparisons of the role of teachers in the U.S. and other countries—or of the role of teachers relative to practitioners in other fields such as medicine and engineering—illuminate how underestimating the professionalism of U.S. educational practitioners in turn undercuts the sustainability and quality of systemic educational reform.

Beyond these problems of disconnects among basic research, applied research, and policy—as well as between researchers and practitioners—the value of innovations is too often reduced to and measured only by immediate improvements on standardized tests of student performance. This focus, though useful within its limits, provides too narrow a framework for evaluating the gains, successes and shortfalls of educational innovation’s process and outcomes. When taken as the *only* measure of worth—and this is how most discussions frame this issue—evaluation based on these limited measures does not provide the public and policy makers with enough knowledge for a continued progression of thoughtful innovations. Sustaining a coherent strategy for *higher-level* student learning (outcomes largely not measured by current high stakes tests) to meet the long-term needs of society then becomes very difficult. For preparing students to compete in a knowledge-based global marketplace, an all-or-nothing improvement strategy that is both focused on immediate results and designed for purposes of ranking rather formatively enhancing learning is self-defeating.

Change is a process, not an outcome; a ‘one shot’ improvement implies that the environment that nurtures the current failure is left unchanged. Funding initiatives should explore ways that current measures of the directions and pace in which schools are moving can alter to provide a constructive, formative relation among research, policy, and practice. Such funding can aid in developing shared conceptions of educational reform that allow practitioners and researchers to assess their continual individual and collective progress based on a dynamic view of the educational system, in which standardized measures of success are only one part of the assessment strategy.

Bridging the Research and Educational System Contexts

We think the central problem in research funding is not only helping to enable success in current innovation efforts, but also empowering continued, deeper improvements in learning through an evolutionary process built into the structure of our society’s educational system.

Otherwise, educators will be inevitably confronted with recurring, discontinuous calls for “reform.” Other fields provide better models of evolutionary advance than does education, in which change is seen as sporadic and following a step function. Every two decades the field goes through a cathartic phase in which immense energy and resources (and political pain) are suddenly invested in “revolutionizing” education to patch up many years of accumulating shortfalls.

To avoid such unproductive and demoralizing attempts at instant innovation (Kaestle, 1993; Kaestle, 1997), the research and policy communities must alter their perspective on the educational system and reconceptualize schooling as a form of social organization that can learn from itself. Many of the problems with reform arise from a view of the educational system as dependent on outside largesse—funding, materials, “teacher enhancement,” research, policies—in which all its practitioners can do is “accept disseminated results” and “deliver instruction.” Without mutual respect and shared expectations among researchers, practitioners, policy makers, and local communities, no model for educational experimentation and evolution will succeed. Even though systemic models of innovation dominate organizational evolution outside of schooling and drive the economics of the workplace, these are largely absent in both practitioners’ and researchers’ views of educational innovation.

In the context of the educational system, we believe enhancing reflective innovation and evolution requires both researchers and practitioners to consider that:

- No sustainable, coherent change can take place without reflective, continual experimentation³ by small groups of students, teachers, and administrators within the target organizational context.
- No seminal experimentation can occur without a research mentality (the formation of testable hypotheses, the habit of reflection), supported by appropriate resources and embedded into the cultural image of the institution as a learning organization.
- The research ethos must exist not only inside the “system” as a single unit of analysis, but inside each of the critical components of the system (i.e., the practitioner, administrative and policy maker communities). Otherwise each component’s approach to innovation will be shaped by divergent goals and measures. Under these adverse conditions, “reform” is necessarily sporadic, dependent on temporary circumstances, and unsustainable.

³The Office of Technology Assessment and a recent PCAST report found that R&D in education is roughly 0.025 percent of all education and training expenditures, a percentage that is small relative to R&D investments in other priority areas and to the overall percentage of US GNP in R&D; technology-based industries spend 3 percent of their sales on R&D, and industry are taking advantage of the latest technological advances, education and training lag further and further behind. This level of investment of 0.025%, coupled with the investment made for the most part to outside the system itself, has led to a bankrupt, static, system.

- Not only strategies evolve; the meanings attached to goals also shift as we learn. Worthwhile strategic goals must not be set in stone; if frozen in time, the objectives sought will become inconsequential, eschewed, or co-opted.
- Scaling-up does not only mean multiplying practices or disseminating outcomes, but also determining the contextual conditions for a similar process of innovation to take place.
- Any sustainable change must at some point be ‘owned’ by an individual, organization, or system rather than being seen as imposed by some external mandate.

How can research funding agencies encourage such a shift in the beliefs and values of researchers, practitioners, and policy makers?

The impetus for these changes in the culture of educational innovation must initially come from the research community. But research can play a significant role in sustainable educational innovation only by developing and testing hypotheses in the challenging real world settings where implementation problems surface. Funders and researchers must then ensure that the formulation, testing, and modification of hypotheses and designs from their inception include practitioners’ perspectives and knowledge. For example, educational research in science and mathematics has gradually moved closer to enactment in contexts of authentic instructional practice. This field has progressed from laboratory studies and mass testing to detailed research in classrooms and careful analysis of students’ conceptual learning. We call for expanding this trend across all disciplinary areas by giving much higher priority to research on whole systems of educational practice, including schools, families, mass media. Such research is currently rare, for all the reasons described earlier, but urgently needed.⁴

To enable conducting the mutually developed, coherent implementation studies suggested earlier as a crucial strategy for educational improvement, the scholarly community and its funders must become more reflective and self-critical about the current process and goals of educational research. Studies of education are similar in some (not all) ways to studies in the sciences, social sciences, engineering, and mathematics. Analogous to research in engineering and the social sciences, educational studies involve developing knowledge about designed, human contexts less constant in their attributes than natural phenomena. As Salomon (1991) describes, educational reform is a complex, multifaceted enterprise similar to aircraft design as a an activity that must embrace complexity in order to reach a solution, and whose outcome includes a detailed blueprint of how to reproduce the process as well as the pitfalls to avoid. The situations studied by educational researchers can be seen as complex systems with sophisticated feedback and non-linear causality, similar to biological or ecological systems, and can therefore benefit from integrated

system research strategies (whose development should be supported more strongly by funding agencies). Beyond independent scholarship, educational researchers also should play a role as intermediaries who enable experts in other disciplines, educational practitioners, learners, funders, and policy makers to understand these complex-system perspectives.

As the field of education changes, the types of research requested and needed alter. In the 1980s, societal concern about educational outcomes led to a variety of descriptive studies designed to assess and understand problems in performance. At the turn of the millennium, now that the causes underlying educational dysfunctions are better understood, practitioners and policy makers are asking researchers to focus on applied studies that improve practice in a sustainable, affordable, and scaleable manner. Requests from the field for research results that inform practice have thus far resulted primarily in evaluative studies that provide limited evidence on whether current educational interventions are worth the cost and trouble involved in implementation. We believe these questions should instead be answered through research funding focused on implementing organizational and systemic processes that optimize investments in innovation and increase the quality and depth of students' learning outcomes.

Another factor influencing the nature of educational research is the rapid advance of information technology and the affordances new media provide for motivating learning and promoting change. Studies of alternative approaches to learning that emerging technologies enable are an important strategic investment for educational research (Dede, in press). As illustrated in our earlier discussion of "knowledge networking," these innovations also might help resolve current problems of schooling and of scaling-up change in a more effective and affordable way than present strategies for improvement.

In response to all these needs, we believe that a balanced portfolio of educational research would include greater emphasis than funders currently provide for these types of initiatives:

- developing a broader base of researchers and scholars capable of studying the complex situations characteristics of large-scale educational innovation in complex environments;
- developing new types of research methodologies to address significant problems of practitioners and policy makers at appropriate levels of aggregation;
- producing a series of research summaries that present validated current research results using the types of evidence practitioners and policy makers find convincing;
- building partnerships with practitioners and policy makers in the design and analysis of mutually developed implementation studies;

⁴ The authors thank Marcia Linn for contributing this comment.

- fostering the potential capability of emerging information technologies to enhance learning and teaching; to improve the organizational efficiency and effectiveness of schools; to enable partnerships for learning among teachers, parents, employers, and communities; and to develop new tools and methods that empower the process of knowledge generation and communication; and
- funding proof-of-concept demonstrations that reproduce and validate an insight or innovation through pilot implementation in a realistic, authentic setting, rather than simply in laboratory trials.

To assess the quality and potential of educational research, we need a balanced portfolio of research capable of sustaining educational reform, including:

- fundamental innovation rather than minor enhancements to existing practices
- a focus on strategic issues of major importance to practitioners and policy makers throughout the multi-year time frame in which research outcomes are developed
- the development of a conceptual framework based both on current challenges in educational practice and on emerging opportunities from potential innovations in technology or theory
- closer research links to basic scientific research that has the potential to significantly improve practice, or to shed light on human learning and coping strategies, and that can provide applied educational research with productive questions of relevance to human knowledge acquisition, retention, and generation
- a long-term perspective, making convincing assumptions about coming advances in technology or knowledge that require immediate, strategic action to prepare educational practice and policy for the future
- a model based on systems thinking rather than reductionist approaches to understanding the interrelationships between an educational intervention and the other processes occurring in its organizational context
- an analysis of already existing, related research that enables this project to extend, complement, or refute similar studies
- analysis of project products and outcomes, including testing the falsifiability of research hypotheses by controlled studies against “current best practice” alternatives to the proposed innovation
- studying successes to “reverse engineer” their generalizable implications for learning, teaching, and organizational structure

- proof-of-concept demonstrations that validate an insight or innovation through pilot implementation in a realistic, authentic setting, rather than simply in laboratory trials
- the generation of fundamental insights that generalize to advance the conceptual frameworks educators use in decision making, or the development of innovations in practice that transfer beyond the local context into many similar situations nationally
- innovations that are affordable, scaleable, and sustainable
- undertaking assertive and proactive dissemination strategies that both inform a broad base of researchers, practitioners, and policy makers and provide support for those interested in adopting or extending the innovation

Not all of these criteria are appropriate for every type of educational research, but they suggest a strategy that could be used when making competitive judgments about what scholarship to propose or what funding decisions lead to an effective research portfolio.

Conclusion

Given that our nation's educational system must evolve to meet the needs of a global, knowledge-based marketplace, then all the groups within that system must contribute towards mutually agreed innovation strategies and outcomes. Any set of stakeholders that is not given validity as a respected and empowered contributor towards improvement will (wittingly or unwittingly) co-opt the change into trusted and known patterns of work and thus defeat any purpose not mutually developed. This is why the prevalent conceptualization of educational research as academic and separate from practice has direct deleterious effects on the relationship between research, policy, and practice.

Reconceptualizing research funding agendas, priorities, and processes to focus more on implementation studies mutually developed by scholars, practitioners, and policy makers is a promising strategy to remedy this situation. For such a reflective, evolutionary innovation process to succeed, researchers, practitioners, and policy makers must all alter their views on the value and conduct of research, as well as on the roles played by these three groups in research and implementation. Acceptance of these shifts in assumptions and actions must initially come from the research community and its funders; to initiate a dialogue, this article suggests first steps in this direction.

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