Realizing Research-Practice Connections: Three Cases From the Learning Sciences

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Abstract: Empirical insights from the learning sciences must be translatable to contexts of application to maximize impact. Despite the importance of dissemination, however, little guidance is available to help researchers proactively bridge the research-practice divide. To address this need, we draw from theoretical perspectives on the utility of empirical research to characterize, illustrate, and discuss three cases involving the communication and translation of research. By offering framework for analysis and initial findings based on three projects in the learning sciences, this paper helps learning scientists conceptualize a range of research-practice connection types and envision how they can take shape in learning sciences projects.

Keywords: research valorization, impact, DBR, RDD, teacher community

Introduction

A robust body of knowledge now exists to describe how policymakers and educators access, value and use research (Broekkamp & van Hout-Wolters, 2007; de Vries & Pieters, 2007; Vanderlinde & van Braak, 2010); various modes through which knowledge is generated and shared (Bauer & Fischer, 2007; Lavis, et al., 2003); and what aspects of evidence-based practice and research utilization in other fields can be applied to education (Thomas & Pring, 2004). However, both the scholarly insights and effective practices have yet to become widely spread. Even though researchers are becoming increasingly required to disseminate research findings among practitioners, few models are available in the learning sciences and many researchers find it daunting. The present paper addresses this need by (a) outlining modalities of fruitful research-practice connections; and (b) analyzing how these modalities are reified in three existing projects in the learning sciences.

Theoretical underpinnings

Factors affecting the uptake and use of scientific outputs

Educational research has long been criticized for its weak link with practice. Explicit attempts to close the research-practice gap have been underway for over four decades. Informed by the work of Rogers (1969), and review of over 2600 research studies, Havelock (1971) published a landmark report on the dissemination and use of scientific outputs. Havelock identified seven general factors that could account for how scientific outputs are taken up and used: linkage, structure, openness, capacity, reward, proximity and synergy. *Linkage* refers to the number, variety and mutuality of research-practice collaborative relationships. *Structure* pertains to the degree of systematic organization around four factors: the resource system, the user system, the dissemination-utilization strategy, and the (coherence of the) message. *Openness* is the belief that change is desirable and possible; this is accompanied by a social climate that is willing and ready for change. Highly correlated with power, size and experience, *capacity* is the capability for retrieving and marshaling resources. *Reward* has to do with the frequency, immediacy, amount, mutuality, planning and structuring of positive reinforcements. Nearness in time, place and context constitute *proximity*, which hinges on familiarity, similarity and recency. Finally, Havelock refers to *synergy* as the number, variety frequency and persistence of forces that can be mobilized to produce a knowledge-utilization effect. In the learning sciences, these issues remain highly pertinent today.

Modes of research-practice interaction

Based on this synthesis, Havelock identified several modes in which those factors can be seen: social interaction; research, development and diffusion (RDD); and problem solving. More recently, attention has also been given not only to the use of scientific knowledge for educational practice (e.g. Hargreaves, 1999; Levin, 2004), but also to how it is produced (Vanderlinde & van Braak, 2010). Specifically, there is growing attention for how researchers and practitioners can collaboratively bear the responsibility for both producing and using relevant knowledge in education. Burkhardt and Schoenfeld (2003) identify seven models to describe the relationship between research and practice, five of which feature strong divisions of labor, relate more to evidence-based practice and align well with the RDD model described by Havelock (the reading model; the summary model; the professional development model; the policy model; the 'long route') and two of which show more characteristics of Havelock's problem solving model (design experiments; and the engineering model). De Vries and Pieters (2007) add an eighth model which shares elements of Havelock's social interaction model and highlights equal collaboration: knowledge communities. Each of these models denotes different assumptions and expectations regarding the roles of practitioners and researchers in the generation and application of theoretical understanding. Taken together, three broad types of research-practice interactions during knowledge production can be distinguished in education today: RDD, design-based (implementation) research DB(I)R and teacher communities (Ormel, Pareja Roblin, McKenney, Voogt, & Pieters, 2012; Pareja Roblin, Ormel, McKenney, Voogt, & Pieters, 2014; Voogt, McKenney, Pareja Roblin, Ormel, & Pieters, 2012). The most dominant model in scientific research, *RDD* is based on the notion that researchers deliver knowledge, intermediaries translate this knowledge into usable products for practice, and that professionals use knowledge in the form of the products. Here, *DB(I)R* to refers to a family of research approaches including design-based research (DBRC, 2003) and design-based implementation research (Penuel, Fishman, Cheng, & Sabelli, 2011), that share the dual aims of (1) deriving new knowledge through (2) collaboration between researchers and practitioners, to iteratively design and implement durable solutions to real-world problems. In *teacher communities*, researchers and educators work together to understand and improve teachers' existing practice, mostly through iterative cycles of observation and reflection.

Toward publically-accessible learning sciences insights

Internationally, enormous efforts have been launched to improve the practical relevance and actual use of research knowledge, especially in the fields of education and health care. As demonstrated above, common types of research-practice interactions have been identified, as well as factors that support success. Additionally, crucial aspects of evidence-based practice and research utilization from other fields can be applied to the learning sciences. However, both the scholarly insights and effective practices have yet to become widely spread in the learning sciences. Even though researchers are becoming increasingly stimulated to disseminate research findings among practitioners, few research programs devote serious attention to preparing their faculty for the task, and many researchers find it daunting. Further, sustainable modalities for such work are lacking, especially due to the fact that dominant promotion and tenure systems reward other output (e.g. scientific publications). For many, the result is that outreach work takes place primarily during personal time and is therefore limited. Guidance is needed to support learning scientists in the daunting but rewarding task of shaping research-practice interactions such that new scientific insights become accessible and usable in practice. The remainder of this paper describes, analyzes, and reflects upon three cases of research-practice interactions intended to facilitate outreach in the learning sciences.

Methods

Focus and approach

Ultimately, this study was undertaken to facilitate learning scientists in perceiving and shaping fruitful research-practice interactions. To reach that goal, we sought an answer to the overarching research question, *"How are the three modalities (RDD, design-based research, and teacher communities) and factors (linkage, structure, openness, capacity, reward, proximity and synergy) reified in existing learning sciences projects?"* The nature of this largely descriptive and exploratory question necessitated the articulation of a set of case studies (Yin, 2014) to help identify observed patterns in factors associated with particular modalities. As this was an initial, exploratory analysis, we choose to focus on projects we already know very well and for which information was readily available (convenience sampling). Within those, we sought one project of each type, i.e. RDD, design-based research, and teacher communities. A final selection criterion was that projects would be sufficiently mature that their core orientation toward research-practice interaction had stabilized (even if their specific activities continued to evolve). Each project selected represents a unique case conducted in three unique contexts with diverse, multifaceted designs, partners, and target populations. The modalities and factors associated with each case represent embedded units of analyses for development of an embedded, multiple-case study.

Data collection and analysis

The data collection and analysis was based on first-hand knowledge of the projects as derived from document analysis, archival records, and attending project meetings and engaging firsthand in project work as participant observers. While the present study was conducted in a post-hoc fashion (after project design and data collection), its reliability and validity are enhanced by access to similar data sources in each project. These variant data sources, as well as the role of each author in providing project leadership, enables a significant degree of data triangulation for embedded analyses within each case. The data analysis was guided by the theoretical framework above, and three sub-questions in particular. Specifically, we sought to understand:

- What are the goals of research-practice interactions in this project, and how explicitly were outreach goals part of the project agenda?
- What features are salient to understanding this project as an example of its type (RDD, design-based research or teacher communities)?
- How does this project realize the factors that are crucial for uptake and use of new knowledge (linkage, structure, openness, capacity, reward, proximity and synergy)?

Each factor (linkage, structure, openness, capacity, reward, proximity and synergy) was examined for each project. The presence of each factor was ranked as being high, moderate, low or variable.

Results

RDD: Science Literacy Initiative

How can we successfully feed 2.4 billion more people by 2050? How can we utilize the Earth's natural resources in a sustainable manner to do so? These are critical questions that face the global community in the 21st Century and lie at the heart of notions of science literacy. Ultimately, scientists, policymakers, and members of the public must work together to find solutions to these significant challenges and pave the way to a sustainable future. This involves as an enhanced capacity, both at the individual and collective levels, to make effective decisions grounded in STEM-informed analyses of complex, real-world challenges associated with agricultural, environmental, natural resource, and technology issues. We confront these challenges and address this need through the Science Literacy Initiative (SLI) at the University of Nebraska-Lincoln, which uses food, energy, and water systems as a platform for a comprehensive suite of programs designed to foster science literacy among PK-16 students, the public, and stakeholders.

A critical dimension of the SLI involves the development of education and communication strategies that effectively reach a diverse array of audiences. This research-practice interaction involves translation of rigorous empirical research on both a) food, energy, and water systems (science) and b) human learning and behavior (social science) into program models and products that effectively foster intended outcomes with target populations. This includes theoretical perspectives and research from basic and applied scientific disciplines, cognitive psychology, the decision sciences, organizational theory, and STEM education. Rather than serve merely as a translational intermediary, however, the SLI spans the research, development, and dissemination domains of the RDD process through transdisciplinary partnerships involving individuals with a range of expertise in relation to specific programs and audiences. While accounting for stakeholder needs, goals, and objectives it an important part of this process, it is nonetheless largely one-directional in design. This linearity presents significant challenges for all research organizations involved in dissemination (e.g., Lavis et al., 2003).

To address this challenge, we theorize and operationalize RDD as a form of 'decision support' for engagement with STEM-based dimensions of everyday life as consumer, citizens, and employees. This is a difficult process, however, as individuals are prone to snap judgments that are quick, irrational, and subject to error. Research and theory from the decision sciences provides a multitude of perspectives on how humans arrive at decisions for complex systems and their associated challenges. These perspectives differ across a number of dimensions that define decision-making along a continuum, such as a) the temporal scales within which decisions are made and b) the number of factors for which decision-makers must account. Some perspectives emphasize intuitive, experience- and instinct-driven decision-making in real-time in high-stress situations (naturalistic decision-making). Others foreground weighing multiple options based upon a complex set of interacting and overlapping criteria. This second perspective, often referred to as multi-criteria decision-making (MCDM), accounts for how decisions about complex issues are made over longer periods of time. We argue that making high-quality, STEM-informed, actionable decisions about complex issues associated with diet, food production, natural resources, transportation, and other contemporary challenges involves being deliberate, rational, and attuned to uncertainties, a process more aptly characterized by MCDM.

To optimize the process and outcomes of the SLI, we emphasize procedural factors identified by Havelock (1971). *Linkage* is a defining element of the initiative itself, being designed to leverage significant and diverse expertise to engage in RDD through multiple programmatic channels to reach a broad set of constituents. Contributors to SLI include faculty from STEM disciplines, social, behavioral, and learning scientists, K-16 educators, and external stakeholders from government and industry. To facilitate initiative *structure*, we have benchmarked all programs (including the resource and user systems) in a shared conceptual framework and set of heuristics for science literacy defined by enhanced proficiency to engage in STEM-informed decision-making.

These heuristics are grounded in theoretical perspectives on multi-criteria decision-making drawn from the decision sciences that foreground framing and problematizing issues, defining their boundaries, identifying and interrogating viable options and strategies for action, and justification of decisions. By grounding programming in contemporary socio-environmental issues, such as water resource use, environmental degradation, food production, and energy, initiative programming also foregrounds *proximity* and close relevance to the lives of individuals served. However, these factors also help illuminate challenges associated with SLI. For example, we remain highly attuned to *capacity*. Personnel resources are crucial not only to knowledge-based contributions to SLI, but also to translational development and engagement. However, the SLI often brings to the fore organizational tensions associated with the allocation of personnel commitments across multiple and competing efforts. *Openness* and *reward*, being largely qualities of the target audience, remain important considerations for program design and for embedded research to understand how initiative efforts and enhanced science literacy influence social, cultural, economic, and civic dynamics. SLI programming must provide a 'value proposition' with intrinsic benefits to its target audiences who, themselves, must be willing to envision change. Each of these factors influence the overall *synergy* contributing to the knowledge-utilization effect underlying the initiative and its emphasis on STEM-informed analyses of complex, real-world challenges associated with agricultural, environmental, natural resource, and technology issues.

DB(I)R: PictoPal

PictoPal is the name of a technology-rich learning environment for early literacy. The primary goal of the learning environment is to teach kindergarteners about the nature of written language. Supporting this goal, the environment also helps children recognize the relationship between spoken and written language; and various functions of print. PictoPal consists of connected on-computer and off-computer activities. The on-computer activities scaffold the creation of written products (e.g. letters, poems, lists). The off-computer activities use prints of the products created with computer support as literary props or for authentic purposes (e.g. letters are mailed, poems are read aloud, groceries are 'bought' in the store corner of the classroom, etc.). Teachers can easily tailor the contents of on-computer and off-computer tasks within each PictoPal module.

The PictoPal learning environment and related scientific understanding have evolved through collaboration between researchers and practitioners. The collaboration revolved around the iterative development of PictoPal prototypes, thereby addressing two challenges experienced by kindergarten teachers. Namely, designing and using PictoPal helped them (1) integrate activities that addressed crucial but typically under-attended learning goals in the Dutch language curriculum for kindergarteners; and (2) develop their competencies for using technology and understanding early literacy. The PictoPal work has yielded both practical and scientific outputs. From a practical standpoint, this work has produced a usable and effective tool that can easily be adapted for a wide range of kindergarten classrooms. From a scientific standpoint, this work has produced insights related to (Citations removed for review):

- Developing (language) software for young children
- Teacher roles during the design of technology-rich curriculum materials
- Teacher knowledge, beliefs and reasoning as revealed through conversations during design
- Teacher beliefs about early literacy curriculum implementation

Through retrospective analysis, we see that this project did realize linkage, structure, openness, capacity, reward, proximity and synergy. *Linkage* was realized through the collaboration with over a dozen participant groups, ranging from individuals to kindergarten teachers within a school, to entire school districts. All participation was voluntary, and mutual benefits were present (data informed theoretical understanding and school decision making, the schools kept the PictoPal resources they helped created and gained access to ones made by others). The *structure* featured systematic organization with regard to expectations and tasks from the research team (resource system), the teacher teams (user system), the implementation and use of PictoPal (dissemination-utilization strategy), and what had been learned as a result (message). *Openness* was largely served by the sampling procedures. Even though individuals varied in their opinions of how desirable and feasible the change would be in their own classrooms, the choice to work with schools that volunteered because they saw intrinsic value in PictoPal typically yielded a social climate ready for change. All iterations of PictoPal design research benefitted from *capacity* within the research team, and most also included involvement of participants with authority and/or experience that further helped marshal resources. Early positive findings related to pupil learning gain from use of PictoPal increased the *reward* for all those involved. Further, the rich insights and usable materials served as positive reinforcements. *Proximity* was achieved by the explicit choice to work face-to-face with teachers in their own schools on a regular and (in bursts) intense schedule. For most participating teachers, this may have been increased by early exposure to materials previously designed by other Dutch kindergarten teachers (familiarity, recency). Finally, *synergy* was present in all iterations through the extremely powerful, shared commitment to supporting pupil learning about early literacy (with different contributions from those involved). For most iterations, this was also the case for supporting teacher learning about technology and early literacy through participation in design teams.

Teacher communities: Knowledge Building

Knowledge building (Scardamalia & Bereiter, 2014) is an educational innovation that emphasizes working as a community to advance the state of knowledge in that community (typically a class). It differs in important ways from other approaches that the learning sciences have produced; although a knowledge-building experience always addresses external requirements such as educational standards, it does not come with a scoped and sequenced curriculum, instructions for teachers, and an imagined endpoint. Instead, the teacher in a knowledge-building classroom needs to learn to help students to: explore their knowledge and interests in a domain, find important questions in that domain to pursue, and to investigate and discuss these questions—and ideas about them—to advance the community's state of knowledge as far as possible. There are principles and heuristics but few prescriptions.

To address the above challenge, we used a community-based approach to advance knowledge building locally by creating synergy between two types of activity: graduate teaching, and collaboration with teachers who are working on knowledge building in their classrooms (Chan & van Aalst, 2006; van Aalst & Chan, 2001). Thus when postgraduate students take our course on knowledge building, the "learning environment" includes teachers working on knowledge building in their classrooms—some already having 8 to 10 years of experience. The graduate students can observe the classes of those teachers and their online work or collaborate with them to try a new idea out in the classroom; some of the teachers also visit the graduate course. This strategy brings together the academic knowledge that graduate students acquire from their course, and which the teachers have limited time to acquire, with the practical knowledge of the teachers. Both the graduate students and teachers benefit from this interaction. In addition, we periodically organize events where graduate students, graduates and teachers come together to share their personal advances and learn about the latest research on knowledge building internationally. We also collaborate with the government to address problems that are important to the community at large (Chan, 2011). As some examples, very early we organized symposia in which graduate students, teachers, and some students from their classrooms worked together on important questions that were holding knowledge building back at the time—how the teacher introduces a question in the online environment. Later on, K-12 student panels shared about their experience with knowledge building. When we carried out a review of current theories of learning for the local government, the most experienced teachers became important collaborators, providing detailed examples of how their work exemplified the theories.

Our group has many of the hallmarks of a learning community (Bielaczyc & Collins, 1999), including shared goals, a sense of belonging to the community, ways of sharing accomplishments, and ways to regenerate membership. The course and symposia provide regeneration. One important signal that we have a community is when teachers who have relied on our assistance in the past become more self-directed and only ask for advice or limited assistance for their own initiatives. Another is that through the teachers own professional work we increase the footprint of knowledge building; for instance, one teacher became a member of the Curriculum Development Committee of the government; another hosted a group of teachers from Singapore who were on a study tour on knowledge building. While this community approach is not scalable to very large numbers of teachers it appears to be sustainable and makes an important contribution to developing scalable practices. Recently we have begun to establish formal partnerships with some of the schools where the teachers work to provide a larger role in professional development for those schools.

Which of the aforementioned elements are present in this approach? *Linkages:* There are a variety of short ad long-term collaborations: between graduate students, between graduate students and teachers, among teachers, between researchers and teachers, and between the researchers, teachers and the government. *Structure*: We maintain websites to share resources for and on behalf of the teachers, create opportunities for collaboration, and opportunities for teachers to share their stories. Apart from symposia, we organize some social events that help to build community, and have recently begun to publish a newsletter. *Openness:* We believe that our model is one in which various participants have voice. Examples are when we have done research that responded to teacher questions. We have created opportunities for graduate students to carry out trials of knowledge building in their own classes, and thereby prepare them for continued work in this area after they graduate. Teachers and graduate students bring in knowledge of other technologies than Knowledge Forum® that enriches what we could offer via professional development. *Capacity:* We have benefitted from government initiatives that align with knowledge building and related funding schemes; for example, a major curriculum reform in the first decade of this century emphasized working with ICT, collaborative learning, inquiry-based learning, and formative assessment, and knowledge building became a way to address all these goals. Currently, local emphasis on knowledge exchange (or valorization of research) stimulates our work. *Reward:* Locally, working with a university-based group to improve learning is desirable for schools. Opportunities to share work and be recognized for achievements also are seen as rewards. *Proximity:* The pedagogical requirements of knowledge building are novel—thus less familiar—but the current climate of educational change is an asset to our work. *Synergy*: Everything is knowledge building—our research, the work of graduate students, and that of teachers and their students.

Cross-case analysis

Table 1 provides an indication of the extent to which each feature is present in each case.

Across these three cases, we can observe both parallels and significant variation in terms of Havelock's procedural factors. Each, for example, relies heavily on diverse and varied collaborative relationships (linkage) within parameters established to define the numbers, types, and norms of community interactions (structure). These factors serve to cultivate a productive organizational environment in which high levels of synergy can be achieved. For example, a teacher community, because it has a large number of participants with varying expertise and interests, can have high degrees of linkage and synergy. Teacher communities also can require a great deal of structure, including the maintenance of technical infrastructure. Some communities such as large groups in social media, however, also can be effective at sharing knowledge but perhaps less so at knowledge construction that builds shared understanding of research results, agendas, and practical problems (Author, 2009). However, variations in individuals' belief and commitment to changes in organizational activity (openness) and/or the social/cultural capital associated with change through these activities reward) can limit the capacity of research dissemination to impact change. Efforts within teacher communities may not be focused on a specific short-term target, and there may not be clear rewards apart from being recognized in the community for one's contributions. In non-professional contexts, SLI-focused activities have the potential to negatively impact one's standing within a community by challenging prevailing norms or established identities.

Table 1. Overview of features in each case

Feature		**RDD**	**DB(I)R**	**Teacher Community**
Linkage	Number and types of collaborative relationships	High—researchers, educators, policymakers, stakeholders	Variable—multi-year and multi-month partnerships between researchers and practitioners	High—short and long-term; researchers, teachers, government
Structure	Degree of systematic organization	High—grounding in theory-based program model for decision-making	High—organized by university team	High—organized by university team
Openness	Belief that change is desirable and possible	Variable—dependent on 'change-readiness' of target audiences	High—due to voluntary participation	Moderate—need to change partly accepted
Capacity	Ability to retrieve and marshal resources	Moderate—needs typically exceed capacity, particularly for personnel	Moderate—high in research team, high in those school teams that included educational leaders	High—if linked to a government change agenda
Reward	Frequency, immediacy, amount of positive reinforcements	Variable—dependent on cultural costs associated with target audiences	Variable—learning gains and teacher professional development generally positive but in varying degrees	Moderate—informal recognition of achievements
Proximity	Nearness in time, place and context	High—direct connections to expertise and lived experience of target audiences	High—direct connections to expertise and practices of participating teachers	Moderate—ongoing so without clear endpoint

Synergy	Number and variety of persistent forces that can be mobilized	Moderate—variable lasting impact on behavior beyond finite programming	High—Shared commitment to pupil learning, with different contributions from those involved	High—Participants contribute in variety of ways

Conclusion and implications

Enhancing the impact of research beyond academia—i.e., on policy-making, educational practice, and society, has never been more important. In an era in which society is much more interested in the return on investment of research funding than in previous decades, governments, research institutions, funding agencies, and the public at large are paying more attention to the benefits of research to society. One aspect of this is increased attention to research integrity (Macrina, 2014), but another is a call to the research enterprise to enhance its impact. For example, in the United Kingdom, the 2014 Research Excellence Framework—its external assessment of funded research—for the first time required "case studies" demonstrating the impact of research on policy-making (http://www.ref.ac.uk/). Indeed, across Europe, the last decade has witnessed increased attention to valorization. Here, valorization refers to the process of value-creation out of knowledge. Specifically, it is concerned with making new knowledge suitable and available for economic or societal use, usually by translating it into high-potential products, services, processes and industrial activity. These considerations seem especially applicable to the RDD modality. In thinking about the products, services, processes and industrial activity in the field of education, it would seem especially important to consider how to establish and maintain connections with the primary creators of broadly used curricula, assessments, and professional development opportunities, because such educational designers wield powerful influence on teaching and learning enactment (Author). These are key linkages and synergies underlying RDD efforts. However, even when these program- and organizational-level factors are high, characteristics of the population to be served are critical, including perceived need for and within-community incentives for change. Findings from learning sciences research can be directly translated into the design of educational programs and resources with potential for significant reach and impact when these factors are aligned effectively.

For DB(I)R and teacher communities, in which the research activities themselves simultaneously contribute to knowledge building among practitioners, Levin's (2013) notion of knowledge mobilization may more accurately describe the vehicles at play, because it stresses the interactive, social and gradual nature of the bilateral connections between research and practice in the field of education. In DB(I)R and teacher communities, researchers and practitioners take each other seriously in genuine collaboration that yields both scientific and practical benefits.

From its inception, the field of the learning sciences has aimed to impact teaching, learning, and behavior in schools, universities and everyday contexts where learning happens. Despite some exceptions, the field has yet to make substantial progress in this direction. Furthermore, public understanding of what learning scientists know about how people learn remains extremely limited. As such, there remain significant opportunities for the field to tackle the problems of research, practice and public understanding of learning. Findings presented here begin to address these challenges. This paper makes a useful contribution by considering three common extant approaches to realizing research-practice connections. It describes various manifestations of the factors that are crucial for uptake and use of new knowledge (linkage, structure, openness, capacity, reward, proximity and synergy). By offering framework for analysis and initial findings based on three projects in the learning sciences, this paper makes a modest but clear contribution toward helping learning scientists conceptualize a range of research-practice connection modalities, and envision how they can be shaped in learning sciences projects. Subsequent work could further operationalize the factors for each modality, as those shaping research-practice connections seek not only conceptual tools, but also instruments that can help investigate and monitor the nature and functionality of specific research-practice connections.

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