Research-practice interactions as reported in recent design studies: Still promising, still hazy

Research-practice interactions as reported in recent design studies: Still promising, still hazy

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Abstract. This study portrays recent research-practice connections found in design research literature focusing on the creation of instructional solutions. Solutions in different stages of development varied greatly in duration, ranging from one lesson to a whole year curriculum, spanned all levels of education, many subjects (science, math, language, culture, teacher education, etc.). Close collaboration between researchers and practitioners was prominent in all of the 18 projects studied. Participants in primary and secondary education projects have quite distinct roles regarding the teaching and researching, but they design their instruction solutions often collaboratively. Nearly all projects reported on how designed solutions were anchored in research, either from literature or from in-house project data. All articles indicated that research fed (re-)design, but few specified how. Based on our findings, we call for increased research and reporting on the specific strategies employed by design research participants to facilitate the production of new knowledge through design of instructional solutions.

Keywords: design research, research practice gap, research and development

Introduction

We view the purpose of educational research as relating to two main goals: to produce new knowledge; and to improve educational practice. While this goal orientation is shared by others (cf. Mortimore, 2000; Bauer & Fisher, 2007), the history of educational research shows that these two goals and have mostly been viewed as mutually exclusive. For decades if not centuries, the goal of knowledge production has been pursued largely through basic research (in nomological, and more recently, interpretivist traditions); whereas and the improvement of practice has been pursued through applied work, which is only just beginning to overcome its second-class stature. This traditional orientation has done much to account for the long-lamented research-practice gap, as has the notion that knowledge flows unidirectionally from research to practice. In contrast, we depart from the mindset that working on these two goals can, and in many cases should, be synergistic and simultaneous.

The call for social science research to embrace a 'linking science' that connects research and practice by bridging the basic and applied research traditions dates back at least to 1899, when Hugo Münsterberg, gave his presidential address at the annual meeting of the American Psychological Association; a year later, the succeeding president, John Dewey, echoed and elaborated on the need for work in this area. Perhaps they were ahead of their time, as the message yielded little impact until Glaser (1976) called for a science of design in education, igniting a debate primarily among researchers and Stokes (1997) fueled the fire with his widely acclaimed book that spoke to researchers, policy-makers and practitioners alike. Stokes' call for increased work like that of Pasteur, which linked basic and applied sciences, helped usher in a new era of awareness and debate about research-practice relationships. In the last decade, researchers, practitioners and policymakers have argued, lobbied and legislated for new forms of research that bring research and practice closer together through mutually-beneficial interactions, many of which link the basic and applied sciences. Among the new forms of research emerging is design research, which addresses the "need for new research approaches that speak directly to problems of practice and that lead to the development of usable knowledge" (Design-Based Research Collective, 2003, p. 5).

Educational design research is "a genre of research in which the iterative development of solutions (e.g., educational products, processes, programs or policies) to practical and complex educational problems provides the setting for scientific inquiry, and yields new knowledge that can inform the work of others." (McKenney & Reeves, in press). Several motives for undertaking design research relate to bringing research and practice closer together. First, because design research takes place in authentic settings and that are rich with, not cleansed of complexity, the findings from these studies stand to have strong ecological validity (cf. Brown, 1992), rendering this kind of knowledge more usable (cf. Lagemann, 2002). Second, because practitioner voices – to varying degrees – shape design research projects, the findings from these studies stand to be more relevant and therefore more usable (cf. McKenney & Reeves, in press). Third, engaging practitioners in the co-creation of new knowledge, which is common in design research projects, is a powerful mechanism for promoting the uptake and use of new insights (cf. van de Linde & ter Braak, 2010). Increasingly, design research is also being introduced to increase the robustness of design practice (van den Akker, 1999) and contribute to much-needed theory building in the arena of educational design. Gradually, examples of design research are cropping up in literature; and the educational design researcher community is beginning to learn from each other's work by way of example. But so far, we know of no effort to examine the complex interaction between research and practice within actual, as opposed to idealized, design studies.

The purpose of this paper is to begin to describe the nature of the research-practice interactions within selected design research endeavors. We do not attempt to provide a comprehensive overview representative of research-practice interaction in all design research projects. Instead, we look for important features relating to one, highly prominent focus, present in many design studies: the design of instructional solutions. We choose this focus for two main reasons. First, when it comes to educational design research, the design of instructional solutions is among the most prevalent orientations found; we therefore assume that this will be useful to many interested in design research. Second, as scholars of instructional design, we applaud the recent renewed attention given to teacher/learner voice, e.g. as demonstrated through the upsurge of user-centered design work; we view researcher-practitioner collaboration through design research as a promising avenue to developing relevant, useful and effective instructional solutions.

Theoretical underpinnnings

Characterizing educational design research

Educational design research is a research approach, not a research methodology; educational design research uses quantitative, qualitative and mixed-methods to answer research questions. There is consensus on some core features of this approach, but also healthy variation in interpretations and uses of the term, design research. Consensus appears to be present on in characterizing design research (cf. Kelly, 2003; Reinking & Bradley, 2008; van den Akker, Gravemeijer, McKenney & Nieveen, 2006; Wang & Hannafin, 2005) as: *interventionist* (undertaken to improve practice); *iterative* (consisting of multiple cycles of research, intervention development, testing and revision); and *collaborative* (involving researchers and practitioners, and sometimes other groups). In addition, educational design research uses existing knowledge to construct solutions to complex educational problems, and produces new knowledge by studying what happens when those solutions come to life in real classrooms. Working systematically and simultaneously toward the *duals goals of knowledge production and solution development* may be considered the most defining feature of educational design research (McKenney & Reeves, in press a).

There is no set process for conducting the ‘manifold enterprise’ (cf. Bell, 2004) of design research. Differences in design studies relate, among others, to grain size of study (e.g. individual learning activity, full year of inquiry science activities); subject areas addressed (e.g. mathematics, science, art, language); kinds of research questions being asked (e.g. about characteristics of the intervention, insights engendered by use of the intervention, or both); scope of implementation (e.g. one classroom, three schools, 50 states), and the methodological traditions of research teams (influencing both researcher values and expertise available).

Design research projects do tend to be long term (Burkhardt, 2006), evolving through multiple iterations of (re)design and field investigation, together with practitioners, to develop the dual outcomes of solutions and knowledge. During the process, it is common not only for researchers and practitioners to collaborate, but to take on multiple roles. Design research participants often become researcher/designer/teacher/facilitators, thus finding themselves playing the conflicting roles of advocate and critic (Design-Based Research Collective, 2003). As has been discussed in literature, the multiple roles present both challenges to rigorous inquiry that values objectivity, and opportunities to incorporate insider perspectives efficiently and effectively in interpreting findings and revising solutions (McKenney, 2001).

In terms of outputs, the kinds of solutions developed through design research varies widely, even when limited to instructional solutions, the topic of this article. What can be expected from the solutions created through design research is that they are derived from a systematic process, initially grounded in existing knowledge and evolving further through empirical testing (cf. Sandoval, 2004). Similarly, the knowledge produced by design research can take myriad forms. For example, the knowledge output may be more closely tied to a particular type of solution, such as Kim and Hannafin’s (2008) principles for grounding the design of web-enhanced case-based activity; contribute more toward theory building, like Thomas, Barab and Tazun’s (2009) theory of transformational play; or describe educational realities as they are, as in Raval, McKenney & Pieters (2010) analysis of Indian para-teacher learning needs. While design research often also contributes to the knowledge production among those participating, a key feature of this approach is that it generates knowledge that can be used by others.

A framework for understanding research-practice interactions within EDR

We view design research as extremely well-suited to the dual goals of producing new knowledge and improving educational practice, synergistically and simultaneously. Central to mutually-beneficial research-practice interaction are two elements: the knowledge generated by research; and the people who produce and use that knowledge to improve educational practice. We also acknowledge that research-practice interaction does not take place in a vacuum. Rather, the context and rationale for interaction influences the research-practice interaction. In design research, the rationale pertains to designing solutions to educational problems for use in particular contexts.

The 'social design' of educational research in general (cf. Wagner, 1997) and design research in particular (cf. Barab, Dodge, Thomas, Jackson & Tuzun, 2007) plays an important, if not determining role in shaping the research activities and – though we might not like to admit it – sometimes even the findings. As mentioned previously, both researchers and practitioners take on multiple, often conflicting, roles during design studies. This is one way to facilitate the flow and uptake of new knowledge. For example, by taking on the role of designer, researchers who are less familiar with classroom constraints may become more sensitized as they gather parameters within which solutions will have to function. Similarly, by taking on the role of researcher, teachers may take a fresh look at phenomena in their classroom, enabled by a new lens or perspective. Playing multiple roles stands to influence the individual participants directly, and through that, the insights which emerge from design studies that can be useful to others. After pointing out that design research is a 'highly-interactional' mode of inquiry (as opposed, for example, to unidirectional), Bauer and Fischer (2007) suggest the need to study researcher-designer interaction using distinctions commonly seen in research on group learning, between cooperation (distributing tasks among partners to make use of complementary expertise) and collaboration (implying that team members equally share rights, duties and abilities).

Design research features the well-informed design of solutions to educational problems. Here, we distinguish three sources of knowledge that are commonly used to inform the design of solutions: literature, project data, practical knowledge – often in combination with one another. Literature-based design is grounded in theory and/or evidence found in literature; this could be considered a loose interpretation of evidence-based work. Data-driven design is steered by empirical findings from field investigation during project development; this often, though not always, generated through a form of evaluation. Building on the notion of teacher practical knowledge, (Verloop, Van Driel, & Meijer, 2001), practical knowledge-informed design incorporates the wide range of insights and knowledge about research, design, teaching, learning and schooling; this includes, but is not limited to tacit knowledge, experiential knowledge, professional knowledge and propositional knowledge. While the first two forms of knowledge are widely accepted as useful inputs for design, appreciation for practical knowledge, especially that of teachers, to inform the design of educational solutions has only recently begun to gain momentum and has been under-represented in design research literature to date (McKenney & Reeves, in press a).

In addition to the solution designed, a major output of design research is new knowledge. As a scientific endeavor, new knowledge generated from design research is at least public (that is, accessible and usable by others) and also often local (for example, contributing to the practical knowledge of researchers and practitioners participating in a particular project). Building on previous work (Edelson, 2002; van Aken, 2004; van den Akker, 1999), McKenney and Reeves (in press b) indicate that the nature of knowledge produced by design research may be one or more of the following: declarative (describing products, concepts or theories); procedural (informing how to take action); or observable (empirical findings or experiences). Each of these has the potential to contribute to theory building. In addition, knowledge produced by design research may be characterized by its focus, for example on teaching, learning and/or resources.

The aim of this study was to explore the research-practice interaction in design studies as reported in literature. We used the considerations above and the following research questions to focus our inquiry:

- What characterizes the projects in general, the contexts in which they take place, and the designed instructional solutions in particular?
- Which participants are involved in design research projects focusing on the design of instructional solutions (e.g., teachers, researchers, facilitators, teacher educators, etc.), what are their main roles, and what is said about the nature of their interaction?
- What sources of knowledge are used to inform design research teams while engaging in the design of instructional solutions (literature, project data, practical knowledge)?

- What do the reports say about production of public and/or local knowledge and what initiatives or perspectives are described to disseminate public knowledge? What do the reports demonstrate about the nature (declarative, procedural, observable); and focus (e.g. teaching, learning, resources) of the knowledge created, and what specific contributions to theory building are evident?

Methods

Project selection

Three groups of descriptors distilled from relevant literature were used to search for projects: terms and types of design research (e.g. “design research”, “developmental research”, “design experiment”); descriptors of the knowledge claim (e.g. “design guideline”, “local theory”) and terms reflecting the approach (e.g. “evolutionary”, “iterative”) in three scientific databases: ERIC, Scopus and Web of Science. To allow in-depth analysis of recent design research, the search was limited to articles published in 2008 and 2009; this resulted in 375 articles. Next, abstracts were screened by two independent researchers in a number of test runs of 20 abstracts each and differences were discussed until agreement was reached. This was done until the inter-rater reliability using Cohen’s κ indicated an appropriate level of agreement ($\kappa > .8$). To be included in this set of recent, educational design research projects exemplifying research-practice interaction, articles had to address the core characteristics of educational design research described previously: collaboration between researchers and practitioners in educational settings yielding both solutions to instructional problems and empirically-based knowledge. Specifically, each article had to meet the following criteria:

- Educational orientation: The project described was developed either within a formal educational setting (i.e., primary, secondary or tertiary education) and/or as part of a teacher professional development program.
- Researcher-practitioner participants: Besides the researchers, the project involved (student) teachers, and/or intermediaries (e.g., teacher educators, content experts, etc.).
- Research contributes to a practical output: The article explicitly discusses the ways in which (design) research informed the design of instructional solutions (i.e., lesson plans, pedagogical strategies, etc.).

– Empiricism in knowledge production: The article is based on the collection and analysis of empirical data.

After initial screening, 172 articles remained for full-text screening, many having been labeled “possibly relevant” due to limited descriptions in the abstracts. During full-text screening, the same criteria were used. Of the 153 articles excluded at this point, most lacked explicit discussion of how research contributed to the design of instructional solutions. An instrument was developed to analyze the 18 remaining projects, as described in the following section.

Project analysis

The analysis focused on the four major themes addressed in our research questions: the characteristics of the projects and the instructional solutions in particular; the participants in design research and their roles; the types of knowledge used to support the design of instructional solutions; and the nature and dissemination of the knowledge produced by the design research project. The analysis instrument took the form of a semi-structured template, used to capture information extracted from each article about the relevant characteristics of each project. Open questions were used to identify specific project characteristics (e.g. location, subject area, duration) and specific instructional solutions being designed. In addition to open comments, participant involvement was analyzed through four items relating to: profession (researcher, practitioner, facilitator, designer and other), the number of each involved, the roles they had, and activities they conducted. Five items were related to the knowledge used to support design (e.g. nature of the design process, type of knowledge used). The knowledge produced and disseminated through each study was coded according to type (observable, declarative and procedural), and explicit contributions to theory-building were also studied. In addition, the common themes within the project set were also sought. Activities undertaken to disseminate research products and findings were noted, as were references to other publications concerning the same project. In addition, characteristics of the studies (e.g., research approach, methodology, key findings, etc.) were extracted to round out understanding of the 18 design research projects.

Throughout the collection and analysis of data, we adopted both a deductive and an inductive approach, starting from pre-determined categories that defined each major theme while also remaining open to the emergence of unique and particular instances across projects. Common patterns and themes were identified across studies and projects through constant comparisons (cf. Denzin & Lincoln, 2000). For two articles, two researchers filled in the instrument independently and discussed differences as to ensure validity in using the instrument. After analyzing all 18 articles, findings were discussed first within the research team and then in a working conference involving scholars with expertise related to (narrowing) the research-practice gap.

Findings

Characterization of the projects, contexts and designed solutions

As illustrated in Table 1, the 18 projects reflect substantial variation across location, educational level, subject area, designed solution, duration and phase. Ten projects took place in the USA, two in China and the other six come from different countries. Seven projects aim at primary education, three at secondary education, six at tertiary level; and two focus on a teacher professional development. The science (n=7) and math (n=3) domains are most prominently present, making up for the three secondary and for four primary education projects. A new course is the focus of twelve instructional designs; three design durations are shorter than that. One project takes place at the curriculum level, two focus on teacher professional development. Technology is featured in eight designs and 13 project reports were from an initial phase of design. Five of these have explicit links with earlier experiences or evolved from earlier research; and four report changes to the design. Five projects are beyond the stage of the initial designs, of which one explicitly addresses the process of scaling up.

Table 1. Overview of the 18 projects studied

	First author	**Country**	**Level**	**Subject area**	**Designed solution**	**Duration**	**Phase of the study in the project**
A	Barnes	USA	Tertiary	Computer science	2 learning games	Hours	First design, one iteration
B	Barton	USA	Primary	Science	course	6 weeks	First design, evolving from a larger research project

C	Birchfield	USA	Secondary	Science	teaching experiment	3 days	First design, evolving from years long experience with the media used and an experienced design team
D	Casotti	USA	Tertiary	Health/ Medicine	course	3 months	First design
E	Cheung	Hong Kong	Primary	Language	lesson	1 lesson	First design
F	Choi	USA	Tertiary	Teaching	learning environment	6 weeks	First design, one iteration
G	Hadjerrouit	Norway	Tertiary	Computer science	course	4 months	In progress, building upon earlier product
H	Hickey	USA	Primary	Science	assessment framework	2 months	In progress, building upon earlier product
I	Lamberg	USA	Primary	Math	module	3 months	First design
J	So	Singapore	Primary	History	learning trail	2 days	First design, one iteration
K	Swain	UK	TPD	Math	professional developmen t program	9 months	First design, evolving from a larger research project
L	Tatar	USA	Primary	Math	module	3 weeks	Going to scale after small pilots
M	Tiberghien	France	Secondary	Science	unit	not specified	10 years
N	van Rens	NL	Secondary	Science	module	3 months	First design, ongoing
O	Zhang	Canada	Primary	Science	project	4 months	3 years
P	Flannery	USA	Tertiary	Manage-ment		6 months	First design, one iteration
Q	Schwarz	USA	Tertiary	Science	teaching framework	not specified	First design, 3 consecutive studies, timeframe not specified, building upon earlier work
R	Gu	China	TPD	Teaching	support system	2 months	First design, building upon earlier work

Participants and their roles

The 18 projects descriptions were analyzed for the roles played by different participant groups. In Table 2, distinctions are made between the profession roles (e.g. a classroom teacher) and roles played in the project (e.g. a classroom teacher who, in the project, also serves as researcher). This table demonstrates that, indeed, multiple roles are often taken on by design research project participants, and which ones were present in these 18.

Table 2. Overview of participants and their roles in each project studied

Project / Profession	Teacher	Researcher	Developer	Facilitator
Teacher	A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R	A, D, E, F, G, M, O, P, Q	A, B, C, D, E, G, H, J, K, M, N, O, P, Q	D
Researcher	*	B, C, E, F, H, I, J, K, L, M, N, O, R	B, C, E, F, I, J, K, M, N, O, R	K, R
Developer			F, L	

* University teachers who collected data in their own classes are included in the teacher row (A, G, P, Q,)

Typically up to five teachers participated in a project, though this number is much higher for professional development programs being developed (Gu, Zhang, Lin, & Song, 2009; Swain & Swan, 2009) or when projects go to scale (Tiberghien, Vince, & Gaidioz, 2009). As expected, teachers all contribute by teaching the newly developed products. In only two cases, their role is limited to this (Hickey, Ingram-Goble, & Jameson, 2009; Lamberg & Middleton, 2009). As shown in Table 2, teachers become involved in research activities as well as design activities.

Four projects (A, G, P, and Q) were conducted solely by tertiary-level teachers conducting design research in their own organizations, being responsible for all design, research and teaching activities (Barnes, Powell, Chaffin, & Lipford, 2008; Flannery & Pragman, 2008; Hadjerrouit, 2008; Schwarz, 2009). These authors publish about the design and/or improvements made to courses for computer science, science teaching, physics and service learning. In two other projects (D, F) tasks are more spread over several participants: University teaching staff are involved in developing a new physiology curriculum (Casotti, Rieser-Danner, & Knabb, 2008) which they also implemented but they were also facilitators for other colleagues who also taught the new curriculum, and they collected student data. Choi and Lee (2009) report about an online learning environment for student teachers, which was developed together with help of others (not further specified) and used in a course by one of the authors. This teacher/co-author also participated in designing the evaluation instruments. The other author was involved in the design process and in research activities, by reviewing the literature, using it to design the online environment, gathering and analyzing data. Work reported by Gu, Zhang et al. (2009) and Swain and Swan (2009) both concern teachers' professional development programs (K, R): aimed at teachers in other educational levels, but themselves working at educational departments at university level. As such, they were involved in designing, researching and using the products. Teachers participating in these programs had to design activities to be tried out in their own teaching practice.

In three projects only (E, M, and O) teachers from primary and secondary education were involved in research activities. Four teachers collaborating to design a lesson observed each other when the lesson was taught (Cheung, 2009), teachers from the university network tested activities to see whether these were robust enough to be done independent from the design team (Tiberghien, et al., 2009), and one teacher co-authored the article (Zhang, Scardamalia, Reeve, & Messina, 2009). In most projects, teachers are involved in the design process as co-designers. They contribute to the choice of topics, fleshing out activities and providing ideas for improvement. For example, the need to redesign the teaching practice regarding geological evolution (Birchfield & Megowan-Romanowicz, 2009) was identified by the teacher, who also defined the learning goals for the lessons designed. The teacher participating with Barton & Tan (2009) introduced food and nutrition as a proper theme for exploring the topic the researchers were interested in. Together with students from his class, this teacher and both researcher designed the activities to be conducted. Some of the projects that went to scale involve teachers only as implementers of new designs or teaching a control groups, while other teachers had been involved in an earlier stage more substantially (e.g. Tatar et al., 2008; Tiberghien, et al., 2009).

Teachers and researchers working together in primary and secondary education projects have distinct fields of expertise. Especially in the small-scale projects, the interaction between them is collaborative rather than cooperative when designing together, both contributing from their own expertise and sharing responsibility for the results (Barton & Tan, 2009; Birchfield & Megowan-Romanowicz, 2009; Cheung, 2009; van Rens, van der Schee, & Pilot, 2009). In studies about the larger projects our impression is that interaction is more towards cooperation (distinct tasks and responsibilities) although often very little details are provided about the interaction.

Typically up to three researchers participated in a project. Researchers were responsible for all research activities in projects in primary and secondary education as well are the principal or co-designer in the projects. Apart from the teachers and researchers, only a few other participants are mentioned. Choi and Lee (2009) discuss the help of doctoral students for evaluating data and of some individuals who assisted with the development of the learning environment; they also had a developer on their team. Tatar, Roschelle et al. (2008) reported on the development of a math replacement unit, which was created by a designer with prior experience writing school mathematics curriculum. In two studies (B, O), students were involved in design activities. Barton & Tan (2009) describe how five students together with their teacher and both researcher thought of classroom activities around food and nutrition and reflected upon these; while Zhang, et al. (2009) invited all students in class to determine which aspects of light were to be studied.

Knowledge sources informing design of instructional solutions

Three sources of knowledge that are commonly used to inform the design of solutions are literature, project data and practical knowledge; these are often used in combination with one another. Figure 1 shows a Venn diagram mapping all 18 projects according to the sources used to inform the development of interventions: literature (literature-based); data gathered during the project (data-driven); and/or the practical knowledge of participants (practical knowledge-informed). Each letter corresponds to an article, as given in Table 1.

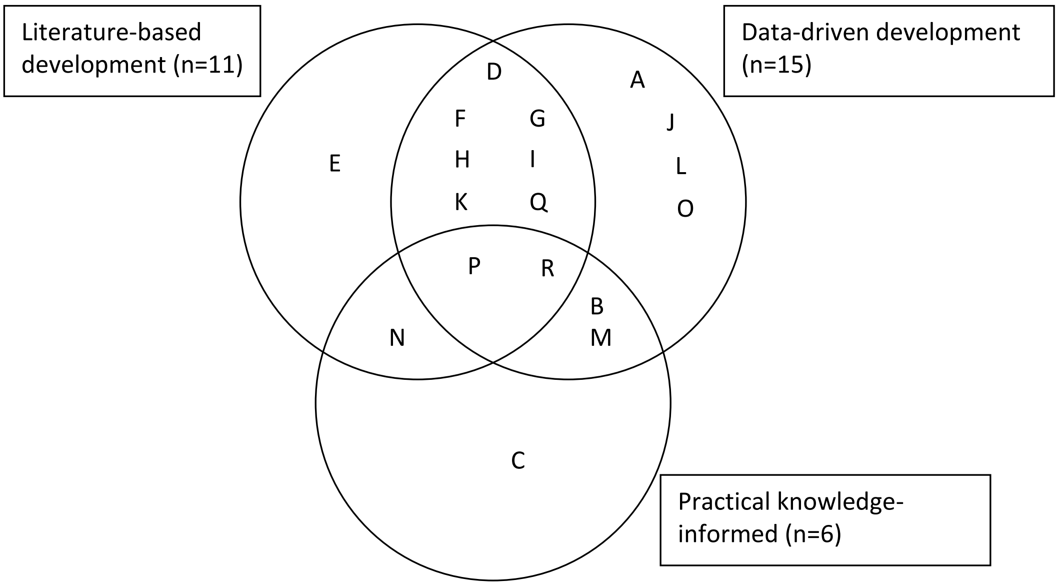

Figure 1. Sources of knowledge used to design interventions according to project descriptions

Only two projects (P, R) clearly indicated that they used all three sources of knowledge to inform their work. Flannery & Pragman (2008) and Gu, et al. (2009) aligned their design approach with strategies from literature. Opinions (beforehand) and experiences from participants informed the (re-)design, as well as systematically gathered data from e.g. surveys and interviews.

Seven studies (D, F, G, H, I, K, Q) used evidence from literature and data. When discussing the literature that is used in a design, it is usually stated that modifications are made (e.g. "a modified version of ...", "draws on the work of…", "was adapted from..."), but only few illustrate how (e.g. Cheung, 2009). Data gathered during the project merely concerns users' feedback (either students or teachers), via surveys and interviews.

Three relied on practical knowledge in combination with either literature (N) or project data (B, M). Van Rens, et al. (2009) state explicitly to involve "teachers in the design process and all benefitted from their teaching expertise. From working together we expected an educational design that would be feasible in practice and would lead to an increase in student conceptual knowledge" (p. 1437). Tiberghien, et al. (2009) brought their design to scale after several rounds of pilot testing.

Six projects describe only one source of knowledge to inform design. For project E, only the use of literature is mentioned to inform the design. In project C practical knowledge seems to be used only to develop new lessons about geological evolution using multimedia, which was designed in a professional learning community. Data is gathered to research interaction patterns, but these are not related to improvements. Projects A, J, L and O refer to project data only. In one case (Tatar, et al., 2008), the phase of the project is to establish the effectiveness of a math replacement unit implemented at quite a large scale and compared to a control group. Where no reference is made to literature to inform the design, this is most likely due to the phase of the project (beyond the initial design, as in L) or to the originality of the topic (e.g. a learning trail, a students' research community).

Knowledge produced and disseminated through design research

The knowledge produced by design research may be: observable (empirical findings or experiences); declarative (describing products, concepts or theories); and/or procedural (informing how to take action). Each of these has the potential to contribute to theory building. Table 3 offers an overview of the public knowledge produced by the projects studied.

Table 3. Public knowledge produced by the projects studied

	First author	**Observable knowledge based on empirical data**	**Procedural / declarative knowledge informing design**	**Implications for theory building are discussed**
A	Barnes	Students' comments Learning gains	Design modifications	
B	Barton	Instances of conceptual 'funds of knowledge' discerned	Examples for teaching	
C	Birchfield	# utterances and turn-taking (Student-Student; Student-Teacher)		3 Design imperatives (based on earlier work and literature)
D	Casotti	Assessment scores and students' confidence ratings on 10 themes		
E	Cheung	Outcome measures for creativity Qualitative explanation for found differences		
F	Choi	Learning gain & learning transfer	Model for problem-solving learning environment	2 Design considerations
G	Hadjerrouit	Students' perceptions	Design	

			modifications	
H	Hickey	Learning gains	Design refinements	(sets of) design principles
I	Lamberg	Excerpts illustrating hypothesized learning trajectory		Activities to initiate/guide learning trajectory
J	So	Findings from observing and listening to students on cultural learning trail	Repairing strategies	Learning scenario
K	Swain	Teachers' views/opinions Observations of teachers' practices		Pedagogical principles (based on earlier work) Factors affecting the impact of professional development
L	Tatar	Effectiveness measures: Teachers' learning gains (after training); Students' learning gains; Variation by teacher		
M	Tiberghien	Class discussion		Framework for designing and teaching mechanics lessons
N	van Rens	Student work	Design set up	
O	Zhang	Teacher-student interaction Students' knowledge gains		Comparison of three collaborative knowledge work models Teacher guidelines
P	Flannery	Assessment data	Design refinements	
Q	Schwarz	Teachers' opinions Data illustrating teachers' use of a pedagogical framework		(hypothetical) principles for advancing elementary teacher knowledge and practices
R	Gu	Teachers' opinions	Lessons learned	

The types of data gathered fall into three main categories, relating to user experiences (A, D, G, K, Q, R), learning gains like test scores (A, D, E, F, H, L, O) and teaching/learning practices (B, C, E, I, J, K, M, N, O, Q), featuring the examination of interaction patterns (Birchfield & Megowan-Romanowicz, 2009; Zhang, et al., 2009), the use of a pedagogical framework (Barton & Tan, 2009; Cheung, 2009; Schwarz, 2009; Swain & Swan, 2009) or the learning process (Lamberg & Middleton, 2009; So, Lossman, Lim, & Jacobson, 2009; Tiberghien, et al., 2009; van Rens, et al., 2009).

In half of all studies, procedural/declarative knowledge informing the design is presented to explain changes made to an initial design, although the information is not very detailed. Also half of all studies offer considerations for designs outside of the study context, partly as results of research, partly as reflections on the 'lessons learned'.

While local knowledge production is likely to have taken place in more projects, only one project description addressed it explicitly (E): Cheung (2009) indicated that the lesson study illuminated teachers' awareness of teaching Chinese writing creatively. Teachers found that being involved in collaborative lesson planning meetings, peer lesson observations and postlesson conferences helped them facilitate creativity in classroom. The report indicates that what they learnt from the learning study was transferred to their everyday teaching. Dissemination of the public knowledge, as summarized in Table 3, obviously took place through the articles found in this search. Reports were studied for additional knowledge dissemination strategies for each project. However, since reporting on a project dissemination strategies is rare in scientific journal articles, these findings are indicative at best, and cannot be considered complete. Still, 12 articles referred to additional scientific publications (articles, doctoral theses); three mentioned project websites; and three described meetings held with schools. References to practitioner publications were not found.

Discussion and conclusion

The aim of this study was to explore the nature of research and practice connections across recent design research literature concerning projects focused on the design of instructional solutions. These connections were analyzed in relation to the projects in general and the specific solutions designed; the participants involved in design research and their roles; the types of knowledge used to design instructional solutions; and the nature of the knowledge produced and disseminated by design research. Following a summary of the main findings and comments on those, this section presents limitations of the study before discussing final considerations about connecting research and practice through the design research projects focused on creating instructional solutions.

The 18 projects described considerable overlaps in roles of teachers, researchers and developers, and in a few cases, facilitators as well. As might have been expected, practitioners have prominent roles in the projects, although the amount of practitioner control over what is being created differs. The practitioner roles seem to be at least partly dependent on: the stage of project development (e.g. initial design vs. scaling up), and the research focus for the paper (determining how much is said about the participant roles). For example, is the project initially undertaken to produce new knowledge, with the design of solutions as a secondary concern; vice-versa; or are they viewed as equally important? A project's stance on this is known to be influenced by many factors, not the least of which is the source of funding behind the work (McKenney & Reeves, in press). Although several studies acknowledge the importance of these multiple roles for the success of design research, little is said about the specific tasks and activities undertaken and how these influenced the work and outcomes of the design research project. Expanded reporting and possibly further research on this area could contribute to gaining a better understanding on how to support design research teams and strengthen the overall research and practice connections.

Most design research projects found in this review use literature and/or project data to inform the design of instructional solutions. Less than half of the reports discuss practical knowledge informing the design of instructional solutions. While this suggests that practical knowledge does not necessarily play an important role in these projects, it is also possible that discussion of practical knowledge was strategically omitted, perhaps in an attempt to render articles more attractive to publication in journals that do not value this orientation. Regardless of the source of knowledge for grounding design (literature-based, data-driven or practitioner knowledge-informed), relatively little attention is devoted to elaborating how designs are informed by research. We find this disappointing, and view such work as essential to advancing design (research) methodology, as well as allowing research consumers to assess the usefulness of others' work for their own situations. We recognize that this may call for alternate publication formats and outlets, which can bring along additional challenges.

Observable knowledge was naturally found in all 18 studies, which shared their empirical findings. Procedural and declarative knowledge contributions were identified that informed the intervention at hand, that could be used for theory building (e.g. on how to solve a particular class of problems), or both. With the exception of one study (E), the construction of new public knowledge is most prominently visible. In so doing, practitioners are collaborative partners in the design, but research, teaching and implementation is most divided among participants. Their involvement is generally not discussed with relation to the production of knowledge or theories (although we assume that university teacher-researchers certainly were involved in knowledge production). The knowledge disseminated by university researchers in the reports studied provides more understanding of the effectiveness of designed solutions than on how those solutions were designed or what, specifically, renders them effective. Beyond what is disseminated by university researchers to other university researchers (e.g. through the journal articles studied), limited discussion is given to dissemination of knowledge and/or solutions outside the local design research context, although we acknowledge that the norms of scientific publication likely account for under-representation of dissemination work in the reports studied. We consider that additional research is needed to explore in more detail the not only the ideal but the actual nature of the knowledge generated through design research, as well as the role of practitioners in the generation of both local and public knowledge, and the strategies and conditions that could encourage broader dissemination and utilization of knowledge generated through design research.

In this study, we chose to focus on the interaction of research and practice in design projects as evidenced through study of: the instructional solutions created through researcher-practitioner collaboration; participants and their multiple roles (e.g. teachers as researchers; researchers as designers), varied sources informing solution development (literature, data and practical knowledge); and multiple forms of knowledge produced (observable, declarative and procedural, each of which can contribute to theory building). While we are confident that the 18 stringently-selected recent projects studied offer useful insights, here we point out several limitations resulting from our methodological choices. First, by valuing empirical scientific articles as data sources, we were unsurprisingly confronted with manuscripts that privileged description of the research over description of the design work; many articles had to be excluded from our review because they did not explicitly describe the activities undertaken by design research teams and/or how research informed the (re-)design of instructional solutions. Second, since we chose to focus on projects featuring the creation of instructional solutions, this study does not portray the comprehensive breadth of design research. Third, while the choice to restrict our findings to papers published in 2008 and in 2009 allowed for in-depth study of recent, projects that met our requirements relating to quality and focus, it limits the possibility of identifying trends that could be evident over a longer period of time. Finally, it is possible that relevant design research projects were omitted not on the basis of content, relevance or quality, but for the simple reason that they did not explicitly characterize their approach as design research or one of the alternate terms used to search the three databases.

Educational design research literature advocates sharing empirical warrants for both design decisions (Barab, Dodge and Gee, 2009; Sandoval, 2004) and theoretical contributions (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Shavelson, Phillips, Towne & Feuer, 2003). We found examples of either of these, although in most cases it is not extensively. While it is possible that research did not inform solution design or contribute to theory-building, we suspect that the former is likely a function of publication bias, and the latter is caused by our focus on research-practice connections. Limited treatment of design pathways and decision making is likely related to our preference for scientific journal articles. We suspect that these same projects may tell very different elements of their same stories in other media. We express our concern at the lack of scientific publication outlets in the field of education that value explication of design processes. Scientific journal articles that carefully articulate how empirical findings contribute to theory-building may not focus on, or have the space available to report on the research-practice connection as well. We know of several projects, including our own, whose reporting is divided into several smaller chunks in order to share specific lessons learned or meet journal word count requirements. Additional research, driven by different methodological choices is needed to explore the connections between empirical warrants and both design decisions and theory-building. In addition, if the potential of design research to inform a broader community of researchers and practitioners is to be realized, then dissemination of knowledge and/or solutions outside the local design project context and/or beyond researcher-researcher media (i.e. scientific journal articles) also warrants attention.

Despite the limitations, our findings do provide in-depth descriptions of 18 carefully selected recent examples of design research that explicitly address research and practice connections during design of instructional solutions. A reciprocal relationship between educational research and practice can be seen, since in most cases practitioners have a substantial role in the creation and implementation of products, though few are involved in the dissemination. An interesting orientation found within many design research projects is held by teacher-researchers who systematically design, research and publish about their courses.

Design research has gained momentum in recent years for several reasons, including its potential to yield knowledge that is (a) ecologically valid; (b) relevant and usable to those who need it; and (c) created in collaboration with practitioners. In addition, design research can contribute to the development of educational design theory. Based on the project reports studied, we see the potential of knowledge production in design research being met: frequently in terms of ecologically valid findings; inconclusively when it comes to relevance and use; and sporadically when it comes to collaboration with practitioners. (Practitioner involvement was high in design and implementation, less so in knowledge production.) With the possible exception of the implementation concerns addressed in two projects, no substantial contribution to educational design theory was identified. As indicated previously, publication bias can account for some of the findings. Nevertheless, we join others in the call for sharing research that features practitioner co-creation of knowledge as a vehicle for use and uptake (cf. van de Linde & ter Braak, 2010); and advances (educational design) theory, e.g. by articulating and analyzing the reasoning and influences shaping intervention development (Edelson, 2002; McKenney & Reeves, in press b). This study may serve as a first attempt to provide researchers, practitioners and policy makers portraits of design studies which – through their focus on the design of specific instructional solutions, forms of participant engagement, use of existing knowledge, and production of new knowledge – speak directly to reducing the research-practice gap.

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