ROLES AND COMPETENCIES OF EDUCATIONAL DESIGN RESEARCHERS: ONE FRAMEWORK AND SEVEN GUIDELINES

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Abstract

Design research is a genre of inquiry in which the iterative development of solutions to problems in practice provides the setting for scientific inquiry. Design researchers and practitioners collaborate to analyze the problems being tackled, and to develop and refine solutions, which are informed by (formative) evaluation along the way. In these studies, the function of the investigator is typically multifaceted, including the roles of: consultant, designer, and researcher. While most design researchers are afforded formal opportunities to develop their research skills (e.g. through seminars and courses on research design, interview techniques, data analysis, etc.), the consultant and designer skills receive far less explicit

attention and tend to be learned informally, at best. If design research is to realize its potential contribution to the field of learning and instruction, then explicit attention must be given to holistically developing design researcher capacity. This chapter first discusses design research, with attention to the goals, nature and processes of this approach, how each role is relevant to each process, and foundational competencies that are required to enact the roles. Then, the chapter turns toward developing design researcher capacity. First, a framework for design researcher learning is introduced, followed by consideration of how that learning takes place, and culminating in guidelines for developing design researcher learning trajectories. The chapter concludes with discussion of these ideas in light of educational research capacity in general.

Keywords

Design research, design-based research, competencies

Rationale

Educational research increasingly focuses on conducting practice-based inquiry to get more insight in and understanding of instructional practices in specific settings and how to take further actions to improve education and ultimately, foster student learning. Conducting practice based-educational research is also seen as a vehicle for teacher professionalization. While conducting this research teachers in schools often work together with educational researchers from universities or institutes for higher education. Increasingly, research conducted in collaboration with educational practitioners can be characterized as educational design research.

Design research is an important genre of research in the field of learning and instruction. In design research, practitioners and researchers work together to produce meaningful change in contexts of practice (DBRC, 2003). Through the collaborative process, empirical investigation takes place and valuable insights are gained for the development of learning theories as well as learning resources (Hoadley, 2004). Commensurate with its twin goals of meaningful change in practice and deriving theoretical understanding, design research communities are characterized with "innovativeness, responsiveness to evidence, connectivity to basic science, and dedication to continual improvement," (Bereiter, 2002, p. 321).

The 'social design' of educational research in general (cf. Wagner 1997) and design research in particular (cf. Barab et al. 2007) plays an important, if not determining role in shaping design research activities (Ormel, Pareja Roblin, McKenney, Voogt, & Pieters, 2012). Researchers and practitioners take on multiple roles during design studies, and these shift over time (McKenney, 2017). However, one can question if researchers and teachers are well prepared to conduct this type of research given the

described. Most academic master programs and teacher training programs do not incorporate the skills needed to conduct educational design research in their curriculum. And while doctoral researchers are afforded formal opportunities to develop their research skills (e.g. through seminars and courses on research design, interview techniques, data analysis, etc.), the development of other competencies required for this kind of research receive far less explicit attention. Most of the time researchers and teachers develop design research skills informally, through experience. Further, cross-cutting and foundational competencies underpin the skill set affiliated with each role.

The purpose of this chapter is to create awareness that doing educational design research is a complex skill and to highlight how training, support and guidance can be given to develop design researcher capacity. Specifically, this chapter conceptualizes design researcher learning that stands to benefit collaboration with practitioners and ultimately contribute to the learning of teachers and their students. In the first half of the chapter, we discuss design research and what it requires. First, drawing on nearly two decades of experience in conducting and mentoring design research, as well as literature on both design research and the design and implementation of instructional innovations, the tasks undertaken in each core design research process are related to three main roles: consultant, designer, and researcher. Second, each role is described and research-based factors known to contribute to the performance of each role are explained. Third, in relation to the roles, four cross-cutting design researcher competencies are described: *empathy* (e.g. fostered when exploring (un)shared goals or becoming exposed to the incentives, motives and reward structures in different settings); *orchestration*, (e.g. developed by simultaneously attending to

research framing, data collection, solution design, implementation, infrastructure woes and stakeholder ownership); creative and analytical *flexibility* (e.g. learned while optimizing the human and material resources available in ways that remain aligned with instructional goals); and *social competence*, including robust repertoire of interaction strategies (e.g. developed largely through exposure). Building on this, the second half of the chapter focuses on developing design researcher capacity. It begins with a framework that articulates crucial design researcher capacities in relation to each phase of the process. Next, principles of situated and whole-task learning are described. Then, we offer guidelines to design researchers and their mentors for creating learning trajectories that foster educational design research capacity. In the conclusion of the chapter, we reflect on the significance of these ideas for other forms of research, and for design researchers in particular.

Conducting Design Research

Multiple Phases of Design Research

Despite the rich variation in approaches to design research, several characteristics of this genre are defining and universal. First, design research features twin goals of deriving new scientific understanding as well as addressing real-world problems in practice. The scientific understanding produced through design research that can be used to describe, explain or predict specific phenomena. Sometimes the findings of design research are used to for more normative purposes, such as the design principles data base with research-based guidelines for technology enhanced learning in science (Kali, 2006). Design research yields varied kinds of interventions to address

problems in practice, including: programs, processes, products and/or policies. Second, to achieve these goals, design studies share certain characteristics. Specifically, design studies are (McKenney & Reeves, 2012): theoretically oriented (building on as well as producing theoretical understanding); interventionist (integrated in research and development efforts to render productive change in practice); collaborative (working with practitioners and other stakeholders); responsively grounded (steered by empirically-based insights); and iterative (featuring successive cycles of investigation over time). Third, while specific processes vary greatly, several key processes are present across design research endeavors. Shown in Figure 1, McKenney and Reeves (2012) identify four key phases: analysis and exploration; design and construction; evaluation and reflection; and – concurrent with each – implementation and spread. As discussed in the remainder of this section, each phase features different core tasks and thus requires a diverse set of researcher competencies.

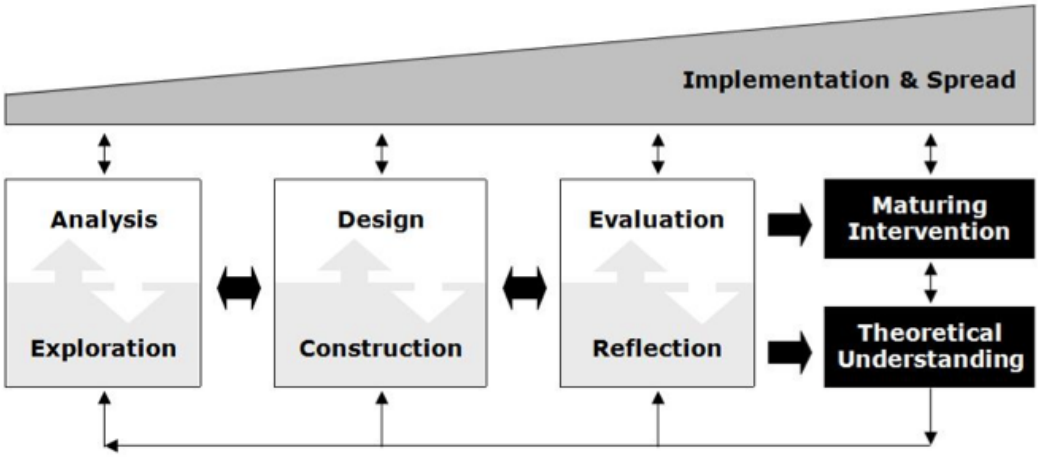

Figure 1. Generic model for conducting educational design research (McKenney & Reeves, 2012)

Analysis and exploration

The analysis and exploration phase yields a better understanding of the problem to be addressed. After initial orientation to the main issues, literature review is conducted to understand and frame investigation of the problem, context, and other relevant issues. Field study is conducted to understand the root causes of the problem(s), identify elements issues worth tackling, and portray any affordances and limitations that should be taken into consideration during design (e.g. stakeholder concerns). Networking and site visits are undertaken to explore other settings in which similar problems have been tackled. The process of reaching out to practitioners, experts and researchers begins to create a network of 'critical friends' who may be able to inform the research. This phase yields a descriptive and explanatory definition of the problem to be tackled and a long-range goal. In addition, initial notions about potential solutions (e.g. constraints, imperatives, possibilities) may be generated. For example, Boschman, McKenney and Voogt (2014) described an investigation during this phase, which yielded a better understanding of the intuitive decisions teachers make when designing technology-rich learning environments. Depending on the problem, context and stakeholders involved, quest for understanding the existing situation involves the problem owners (typically practitioners) and often experts.

Design and construction

Interventions to address the problem are explored and mapped out during design, then build and refined during construction. The processes of design and construction are systematic and intentional, but they also include inventive creativity, application of emerging insights, and openness to

serendipity. Throughout this phase, ideas about how to address the problem tend to start off rather large and vague; and gradually they become refined, pruned, and operationalized. The work is guided by theory, as well as local expertise and inspiring examples. During design, potential solutions are explored by: generating ideas; considering each; and checking the feasibility of ones that seem the most promising. Once a limited number of options have been identified, potential solutions are gradually mapped from a skeleton design to detailed specifications. Then, the solution is constructed, usually through a process of prototyping. Early prototypes tend to be incomplete; sometimes several are tested. Later versions are usually more detailed and functional. Often, the design and/or construction processes lead to new insights, prompting new cycles (e.g. revisiting the setting for additional context analysis). Two main types of outputs emerge from this phase: products describing design ideas for the intervention (e.g. key characteristics of learning activities), and products embodying design ideas for the intervention (e.g. learning activity worksheets). Edelson, Gordin and Pea (1999) offer both in their paper on inquiry-based learning through technology and curriculum design, which provides key design principles (describing the design) as well as specific examples from their own work (embodying the principles). In some projects, practitioners are more active in this phase (e.g. leading or collaborating during creation), but in many projects, the role of practitioners is more reactive (e.g. providing comments on initial ideas).

Evaluation and reflection

Initial ideas, partial prototypes and full designs are the objects of evaluation and reflection. Evaluation usually takes place through developer

screening, expert appraisal, pilots and/or tryouts, each of which could use a variety of instruments (e.g. document analysis schemes, interview protocols, per/post tests). Developer screening helps critique internal consistency and alignment with design goals through a formalized process of examining designs in light of initial intentions. Expert appraisal features external review to validate or improve specific aspects of the design. Pilots help understand how interventions will perform; they are typically conducted early, under semi-authentic conditions (e.g. in pull-out classes, taught by the designer, or with volunteers). Tryouts are conducted in fully naturalistic settings; they can yield insights into various aspects of design (e.g. soundness, local viability, effectiveness). Reflection pertains to retrospective consideration of the evaluation data and experiences. Practitioners sometimes participate in expert appraisals and often participate in pilots and tryouts. This process is illustrated by Long and Hall (2015), who report multiple evaluations (related to three design cycles over a period of six years) in which digital storytelling was explored as a means to enhance pre-service teachers' reflective practice.

Implementation and spread

Throughout the three phases described above, attention is given to implementation and spread. Implementation entails adoption (deciding to engage with the intervention), enactment (the intervention takes place) and sustained maintenance (continuing the intervention in a sustainable way). Spread pertains to the diffusion and dissemination of key ideas and/or the intervention itself. Practitioners are typically key players in the processes of implementing and spreading interventions, as well as those underlying ideas that hold practical application. For example, Bakah, Voogt and Pieters (2012)

described stakeholder perspectives on the large-scale implementation and sustainability of re-designed technology curricula in two polytechnics in Ghana.

Multiple Roles

As may be gleaned from the descriptions above, the tasks undertaken in each core design research process involve multiple roles. While additional subtle differences could easily be identified, we distinguish three different and crucial roles that design researchers play as they interact with practitioners throughout entire projects, and within specific phases: consultant/facilitator, designer, and researcher. Below, we explain what is meant by each role, relationships to the design research phases, and note key factors that contribute to role performance.

Consultant

In line with the breadth of educational consultant work, fulfilling this role includes offering of professional development opportunities, networking opportunities, and consultation with practitioners (Matthews and Foster, 2005). An important part of professional development, consultants play a crucial role in supporting strategic planning (Krabbe-Sillasen & Valero, 2013). Good consultants work collaboratively with stakeholders on problem definition and framing, program development that explicitly involves the target community in planning, and joint research and evaluation (Nelson, Amio, Prilleltensky, & Nickels, 2000). Further, a crucial function of the consultant is sustaining contacts within professional learning networks (Krabbe-Sillasen & Valero, 2013) and facilitating access to additional

expertise. And, as the term suggests, this role includes consultation. Whereas educational consultants in higher education typically work with individual instructors (Brinkley-Etzkorn, Schumann, White, & Smith, 2016), those in K-12 settings must be able to accommodate both individual and team needs (Matthews and Foster, 2005). While some consultants may remain external and share expertise on an episodic basis, others work as process-oriented collaborators, often serving students directly (individually or through co-teaching) and sharing responsibility for them (Kirschenbaum, Armstrong, & Landrum, 1999). Thus, in recent decades, educational consultants have grown to take on the role of change agents and at times, actively participate alongside their clients.

In design research, this role is especially required during analysis, to help stakeholders expose their problems and knowledge thereof. But it is also present in design in the form of expertise sharing and structuring human processes. During evaluation, the consultant role centers on helping to understand what is happening and troubleshooting. During implementation, the consultant role includes the modeling, coaching and serving as program champion. This can include helps others to get/stay in touch with their reason for being involved, which is often tied to a sense of moral purpose.

Designer

A designer is one who plans the appearance, form or workings of something that does not yet exist. Educational designers plan and typically help construct innovations in the form of programs, processes, products or policies. Good designers understand the processes, perspectives and practices that enable their work. While the processes that facilitate educational design include analysis, design, development, implementation

and evaluation (sometimes referred to as ADDIE), different experts emphasize different facets. For example, Hoadley and Cox (2009) consider requirements, specifications, building, deployment, maintenance, and redesign to be key stages. In addition to an iterative and interactive (as opposed to linear and isolated) design process, Schunn (2008) notes the following processes have been shown important in engineering design: exploring problem representation, creating requirements and metrics, exploring alternatives, and exploring end-user perspectives. Throughout these processes, Burkhardt (2009) emphasizes that robust educational design is research-based, starting with review of research, of craft-based knowledge, and of earlier innovations and informing design and development through an iterative process that yields feedback from trials. Further, good designers are aware of the perspectives guiding their work. This includes values such as usability, usefulness, participation, or user-centeredness (Hoadley & Cox, 2009) that underpin their decisions. For example, Visscher-Voerman and Gustafson (2004) identified three paradigms that explained the decisions made by 24 expert designers in actual projects: (1) particularly high value on expert knowledge, including a systematic process (instrumental); (2) sharing responsibility and with clients and placing high value on client need articulation (communicative); and (3) relying heavily on user ideas for the design as well as information underpinning it (pragmatic). Finally, a key element of designer work is developing their design repertoire. Experts have stressed the need for designers to develop or adopt guiding principles, the design patterns, and varied techniques (Hoadley & Cox, 2009). These are needed in relation to both more general design insights (e.g. knowledge of how people learn, media selection, subject matter research and task analysis or more specific

insights (e.g. domain expertise, storyboarding, editing, scriptwriting (MacLean & Scott, 2011; McKenney & Visscher-Voerman, 2013).

In design research, this role is of course heavily present during the design and construction phase, steering the design process and shaping the designed products. However, it also plays a role in other phases, as foundational knowledge for design continues to develop. Because design researchers develop interventions to address practical challenges, they are served by understanding of the interactions of the design, how it is used and the people who it aims to serve. Burkhardt (2009) refers to this as strategic design, and it includes: identifying a specific opportunity for improvement; choosing or devising a model of change; identifying the resources that are needed to do the job well and the compromises that are acceptable; recognizing and questioning constraints; and advising stakeholders on the likely implications of their various decisions and offering alternatives where appropriate (Burkhardt, 2009).

Researcher

The role of researcher pertains to conducting systematic investigation to develop new knowledge (facts, principles, theories, etc.). As such, their primary tasks are to design studies, collect and analyze data, and report the findings, in ways that are consistent ethical and legal guidelines (ESRC, 2001). Increasingly, researchers, practitioners and policymakers are calling for strengthening attention to the researcher's skills for disseminating and facilitating the use of new knowledge. While measuring societal impact remains challenging, some funding organizations and universities are beginning to include this facet in their assessments of research productivity (Levin, 2013; McKenney & Visscher-Voerman, 2013). This can be visible

through unilateral approaches such as writing accessible publications for practitioners, or more bilateral links between research and practice which leverage the interactive, social and gradual nature of knowledge production by stressing the cooperation between researchers and practitioners during the co-creation of new knowledge (Levin, 2013; Vanderlinde & van Braak, 2010). While there is little debate about the importance of these basic researcher tasks, it is important to note notions of 'good quality research' vary greatly from discipline to discipline (Vanderlinde & van Braak, 2010), and that even within disciplines, the epistemologies of scholars (and for graduate students, most notably the epistemologies of their advisors), differ tremendously and sometimes even conflict (Metz, 2001). Thus, another task of the researcher is to develop productive habits of mind. This includes becoming acquainted with the literature of a field and socializing into its disciplinary norms and identities (Golde, 2007). Further, researchers need to develop sensitivity to the fact that cultural assumptions and reflections of status can implicitly be built into theory, research questions and methodological choices (Metz, 2001), as dealing with one's own position presents a substantial epistemological and ethical consideration (Scott, Hinton-Smith, Härmä, & Broome, 2012).

In design research, the researcher role is most clearly present during the phases of empirical investigation: analysis and exploration, and evaluation and reflection. But researcher expertise also serves design, e.g. by providing literature-based insights to ground the design and anticipate ways to increase its effectiveness, usability and relevance. Because design research inherently involves multiple areas of focus (e.g. questions to probe a problem, understand how a solution works, or assess the quality of an intervention), a broad understanding of qualitative and quantitative methods

helps researchers to conceive of different kinds of questions that could be asked at different stages of inquiry and to align approaches accordingly (McKenney & Visscher-Voerman, 2013). This ability is crucial to the tighter integration of research and development, which can render educational research "more useful to practitioners and to policymakers, allowing the latter to make better-informed, less-speculative decisions that will improve practice more reliably" (Burkhardt & Schoenfeld, 2003, p. 3).

Cross-cutting Competencies

The descriptions above included key aspects of each role. Reflecting on these aspects across all three roles, several foundational competencies can be discerned, which are crucial to fulfilling each; orchestration, empathy, flexibility and social competence. Asserting that these foundational and cross-cutting competencies can help design researcher performance within and across each role, the remainder of this section elaborates how and why.

Orchestration

Orchestration in the classroom pertains to the design, enactment and management of diverse interactions and processes at multiple levels simultaneously: individual, in small groups or for the whole class (Prieto et al, 2011). In design research, orchestration pertains to coordination of the many and diverse activities that are happening in parallel. This competency is needed for simultaneously attending to key aspects of each phase (e.g. research framing, data collection, solution design) as well as implementation and spread (which also include infrastructure woes and stakeholder ownership).

Orchestration is required to fulfill each of the aforementioned roles. For the consultant, it is important to be able to oversee and support the overall change process, (Matthews & Foster, 2005), which can also include being able to coordinate the mobilization of external resources as part of strategic planning (Krabbe-Sillasen & Valero, 2013). For the designer, project management, monitoring and quality assurance skills and have been identified as crucial in instructional designer competency frameworks (MacLean & Scott, 2011). This can also include working to retain as much space as possible for the creative talents in a design team, and the systematic development that refines the products (Burkhardt, 2009). And for the researcher, management of parallel processes has been identified as a crucial skill for researchers by the United Kingdom's Economic and Social Research Council (ESRC, 2001), which supports not only the production of new insights but also their mobilization for use in policy and practice (Levin, 2013).

Empathy

Empathy concerns the sensitivity to and understanding of others, their situations, concerns and feelings. In design literature, empathy is seen as an aspect of the design process that is influenced by the expertise of the designer, which can be enriched through the use of specific techniques (Kouprie & Visscher, 2009). In design research, empathy is needed for exploring and attending to the needs, wishes and concerns of stakeholders; creating designs that are usable, practical and congruent with stakeholder concerns; help researchers understand and interpret (especially qualitative) data; others take into account (un)shared goals or become exposed to the incentives, motives and reward structures in different settings.

Empathy especially serves the roles of consultant, designer and researcher. Understanding the perspectives of consultees is important for consultants (Brinkley-Etzkorn, Schumann, White, & Smith, 2016). As researchers call for consultants to recognize the wealth of knowledge inherent among those that live the day-to-day in educational contexts (Nelson, Amio, Prilleltensky, & Nickels, 2000), an understanding of their needs and wishes, constraints and rewards can be crucial to being able to leverage that expertise. Further, the consultant's own level of enthusiasm has been cited an important factor for success (Kirschenbaum, Armstrong, & Landrum, 1999; Matthews & Foster, 2005). Designers also possess empathy, and continuously seek to understand the (social) dynamics of the systems they wish to improve (Burkahrdt, 2009) and the end users of specific designs Schunn, 2008). For the researcher, a basic understanding of practitioner perspectives can help in research planning and execution such as anticipating the feasibility or resistance to various data collection approaches. It also helps researchers attune dissemination efforts to user needs (Vanderlinde & van Braak, 2010) and develop appreciation for different kinds of research along with any accompanying tacit assumptions (Metz, 2001).

Flexibility

Flexibility is the capacity of an individual to adjust to new or unexpected situations. Both cognitive flexibility, the ability to think about more than one task at a time or to switch quickly between tasks (Cañas, Quesada, Antolí, & Fajardo, 2003; Spiro, 1988), and psychological flexibility, the ability to change or balance one's standpoint, perspective or convictions given multiple priorities (Kashdan & Rottenberg, 2010), are important for

the design researcher. Flexibility is needed for balancing well-framed investigation with open-mindedness; staying focused on design goals and utilizing unplanned opportunities; drawing conclusions and deriving new questions. Such flexibility also serves orchestration – e.g. optimizing the human and material resources available in ways that remain aligned with overall project goals.

Flexibility is important for each of the aforementioned roles. It benefits the consultant by enabling perspective taking. This is important for understanding value (in)congruence between different stakeholders, as well as for engaging in the self-reflection that consultants need to understand their role and functioning when engaging in transformative projects (Nelson, Amio, Prilleltensky, & Nickels, 2000). Flexibility benefits the designer because it aids in exploration of productive habits of mind (Tracey & Boling, 2014) as well as in 'trying on different hats' to become attuned to various values and considerations that drive a specific design project, which can also include the designer's own tricks and traps such as design fixation or groupthink (Hoadley & Cox, 2009). Flexibility benefits the research process by helping understand and leverage conceptual and methodological insights from other disciplines (Metz, 2001) as well as by enabling the adjustment of methods and schedules to opportunities in the field. Further, it helps the researcher as a developing human to see and understand aspects of themselves as well as their participants (Scott et al., 2012), to identify how implicit or explicit allegiances might be connected with other factors such as class, race, or gender (Metz, 2001), and – especially for those who are balancing research alongside complex and demanding home and work lives – to adopt of new ways of interacting and challenge existing habits (Golde, 2007).

Social competence

From early in design research trajectories, social competence is important. While nuances in definitions vary, experts agree that social competence concerns the receiving, experiencing/processing and sending of verbal and non-verbal communications with others (Feldman, Philippt & Custrini, 1991; Haberstadt, Denham & Dunsmore, 2001). Social competence is needed to develop trust, build relationships, invite people to feel safe and speak frankly; during design, these skills are needed to negotiate design team tensions and to stimulate new thinking; during evaluation, these skills help engender cooperation, ease frustrations and encourage participants to see things through and remain objective until results are in; for implementation and spread these skills are needed to provide leadership and model positive attitudes.

Social competence is important for all three roles. Consultants require effectiveness in areas of interactive communication (Kirschenbaum, Armstrong, & Landrum, 1999) including maintenance of stable contacts (Krabbe-Sillasen & Valero, 2013). Social competence helps them identify and merge the strengths of different partners as well as, and where appropriate, engage boundary spanners (Nelson, Amio, Prilleltensky, & Nickels, 2000). Internationally recognized frameworks of educational designer skills emphasize factors related to social competence, including leadership, communication and client management (MacLean & Scott, 2011). Further, designers aiming for large-scale impact (such as curricula for widespread use) require social competence to network with the public and the media, as well as policy makers, funders, and fellow designers (Burkhardt, 2009). Further, the work of researchers has long been recognized as highly social, relying heavily on verbal and text-based discourse for researcher-

respondent, researcher-researcher and researcher-audience interactions. Social competence is required during most interactions with participants and is crucial for particularly meaningful encounters such as in-depth interviews, which rely heavily on rapport, humor and humility (Scott et al., 2012; Vanderlinde & van Braak, 2010). It also supports knowledge mobilization (ESRC, 2001; Levin, 2013) and communications with fellow researchers, which are crucial not only for examining methods and findings, but also for developing self-awareness and socializing into the profession (Golde, 2007; Scott et al., 2012).

Developing Design Researcher Capacity

Design Researcher Learning Framework

In the preceding sections, we have discussed the nature of design research and the importance of educating design researchers with varied sets of skills to interact with practitioners. Key phases of design research were articulated (analysis and exploration, design and construction, evaluation and reflection – each of which interact with implementation and spread), as well as the main activities undertaken and the roles of practitioners in each. Thereafter, three different and crucial roles played by that design researchers were discussed. Descriptions of each role (consultant/facilitator, designer, and researcher) highlighted competencies needed for each. Finally, four cross-cutting and foundational competencies were identified and each was discussed: orchestration, empathy, flexibility and social competence.

Based on these discussions, Table 1 presents a framework for organizing the focus of design researcher learning. It articulates crucial areas

in which design researchers learn through and for collaboration with practitioners. The columns emphasize how multiple roles and competencies come into play within specific phases while the table as a whole illustrates the diverse capacity needed across entire projects. While individual development and needs would vary highly, the table could be helpful for shaping expectations and targeting learning supports to design researchers at various points in time.

Table 1. Design Researcher Learning Framework[1]

Researcher learning about		**Analysis & Exploration**	**Design & Construction**	**Evaluation & Reflection**	**Implementation & Spread**
Roles (key *work* in each phase)	Consultant	**Gets people to expose their (knowledge of) the problem(s)**	Supports design with expertise; manages people processes	Trouble-shoots when plans derail	Supports with advice/expertise; champion, moral purpose
	Designer	Gathers descriptions and explanations	**Crafts design process as well as designed products**	Recommendations for revision/use	New ideas for what could (not) work
	Researcher	**Frames and studies problem**	Supports design with research	**Rigorously investigates solutions**	Observes to broaden understanding of context
Cross-cutting competencies (key *uses* in each phase)	Orchestration	Literature review Field study Site visits & networking	Exploring solutions Mapping solutions Constructing solutions	Screening Expert appraisal Pilots Tryouts Structured & organic reflection	Adoption Enactment Sustained maintenance Dissemination and diffusion
	Empathy	Attending to needs, wishes, concerns of stakeholders	Creating designs that are usable, practical and congruent with target group needs/wishes	Understanding and interpreting data	Understanding how designs fit (or not) in specific contexts
	Flexibility	Critically investigate problem; uncover opportunities	Remain focused on achieving goals; Seek creative alternatives	Deduce and induce; Question why and what if	Goal-oriented improvisation
	Social competence	Developing trust, building relationships, inviting frankness	Negotiation, stimulation	Engendering cooperation, mitigating frustration, encouraging objectivity	Providing leadership, modeling positive attitudes

[1]Bold denotes especially heavy emphasis on this role in this phase

Situated and whole task learning

Rationale

Taken together, the roles and cross-cutting competencies design researchers must acquire (articulated in Table 1) speak to the complexity of this form of inquiry. In addition, every setting is different, the problems to be tackled are rarely well-defined, and there are many different ways to go about solving them. To develop the skills required to solve real-world problems, design researcher learning must be situated in the complex reality of everyday educational settings. This kind of a situated and whole task approach to learning, which is rooted in social constructivism, is becoming increasingly common in the field of education (Van Merriënboer & Kester, 2008). In a whole task approach, learning takes place by working on meaningful situated tasks that demand certain skills and knowledge to perform that task.

Definition

A whole-task approach to education advocates using real world problems and the integration of supportive contents, knowledge, skills, and attitudes, leading to learning situations that can be deemed as a coherent, interconnected, and meaningful whole. This is opposed to a fragmentized and compartmentalized learning situation, where learners can have difficulties combining pieces of information, and integrating knowledge, skills and attitudes, which results in low transfer of learning (Van Merriënboer & Kester, 2008). Different whole-task models aim at supporting the development of training programs for learners who need to develop and transfer professional competences or complex cognitive skills to an increasingly varied set of real-world contexts and settings. These models try

to deal with complexity without losing sight of the relationships between elements (Van Merrienboer & Kester, 2008).

Given the complexities inherent in conducting educational design research, whole task models can provide useful insights in how to help researchers to develop their expertise. They accommodate the development of multiple competences as needed when taking on the different roles in the four phases of the design process while working on design studies rooted in real-life settings. Three models are described here: Elaboration theory (Reigeluth, 1987; 1999), goal-based scenarios (Schank, 1993/1994), and four- component instructional design (Van Merrienboer, 1997).

Reigeluth's (1987; 1999) elaboration theory is a precursor of the whole task approach, and emphasizes staring with a simplest version of a learning task or domain and working toward more complex versions. It starts with an overview of the topic and zooms in on the related aspects of a topic. In essence, the theory focuses on sequencing instructional concepts and theoretical domains. Learning content (conceptual and theoretical) and related support aims toward the integration of knowledge, skills, and attitudes in which constructing mental models is central. For the design researcher, this might include mental models of the overall and phase-specific processes, or the roles and how to enact them.

In his theory on goal-based scenarios, Schank (1993/1994) emphasizes the need to practice skills using relevant content knowledge to help learners to achieve their goals. Learning by doing is a point of departure and to support this learning, seven components are of importance: goal, mission, cover story, role, scenario operations, resources and feedback. Goal-based scenarios stimulate the integration of knowledge, skills, and attitudes in meaningful settings and stress the importance of learner control over

contents and strategies. This framework can be used to design various learning trajectories, including computer-based learning environments (Schank, Fano, Bell, & Jona, 1994). We have incorporated relevant aspects of these components into the guidelines for design researcher learning presented in the next section.

Van Merrienboer (1997) developed the "four component instructional design" (4CID) model. Learning tasks, supportive information, part tasks and procedural information are the four components that should be designed in order to foster the learning of complex cognitive skills. Whole learning tasks are the backbone, and sequencing learning tasks from simple to complex – while giving support but also fostering self-directed learning– should help develop learning and transfer. Van Merrienboer (1997) also stresses the importance of learning in authentic settings, and draws on the importance situated learning (Lave & Wenger, 1991) which emphasizes that learning take place in the same context in which it is applied. Fostering educational design researcher capacity mostly takes place while conducting a design study in practice and thereby is in a situated learning context where authenticity is guaranteed.

Relevance to the three roles

The importance of a whole-task approach and situated learning can further be examined with regard to each role. For example, Handley, Clark, Fincham, and Sturdy (2007) stress that consultants learn the practices and identities appropriate to joint projects through participation in various workplace communities. Translated to the learning of design researchers, this would include (a) the dominant workplace community associated with the consultant's current place of work (typically a university for employment

and a school for the research); (b) a wider network of practice across organizations which employ consultants with similar roles (in this case, other educational design researchers); and (c) peripheral communities which less directly influence the development of identity and practice (such as a research school).

Experts on the learning of educational designers stress several considerations that point toward the value of whole-task and situated approaches. First, they stress the need for novice designers to be exposed to design models that encompass the whole design process (McKenney & Visscher-Voerman, 2013; Tracey & Boling, 2014). Second, the crucial role of firsthand experiences for designer learning is widely recognized (Hoadley & Cox, 2009), in part because designers frequently reason from previously encountered solutions (Tracey & Boling, 2014). Third, experts note that designer learning is predominantly informal and on-the-job (Yanchar & Hawkley, 2014), situated more in the work of designing than anywhere else. Finally, whole task models help us attend to not only core design tasks but also to productive design habits. An example of this is the crucial habit of designer reflection (Hoadley & Cox, 2009; Yanchar & Hawkley, 2014) which, if well-timed and executed, can yield important and/or timely insights for live design work, as well as for the designer's own professional learning.

Also from the perspective of the researcher, whole task and situated approaches are also important. Their complexity often prompts researchers' 'need to know' about new methods, thereby stimulating the growth of quantitative and qualitative skills (McKenney & Visscher-Voerman, 2013). Especially for researchers new to the field or to this genre of inquiry, whole task and situated approaches support scaffolding during the transition to independent research – a notoriously important and difficult step for

doctoral students (Gardner, 2005). The emphasis on whole, authentic tasks facilitates enculturation into the academy, for example by participation in disciplinary cultures (Gardner, 2008). It also offers exposure to the complexity, and ambiguity of real-world settings, which helps researchers develop understanding of epistemological variety and even tackle emotional challenges (Metz, 2001). These experiences can provide focal areas for structured reflections, which are extremely valuable for learning to share and debate difficulties, develop researcher identity, and empower researchers as professionals (Scott et al., 2012).

Guidelines for design researcher learning trajectories

In the preceding sections, we have discussed the nature of design research and a framework depicting the phases in the process, the roles involved, and the competencies needed. Taking this framework and the theoretical ideas concerning whole-task approaches for (situated) learning, we offer guidelines to help learners and their mentors to foster the capacity development of design researchers. Specifically, we discuss seven guidelines and offer examples of how these guidelines can be used in practice. The guidelines can be used to shape not only individual learning trajectories, but also group ones.

Guideline 1: Assess the existing design researcher (learner) capacity

To set up learning trajectories for learners or groups of learners, it is important to obtain insight into the capacities of the learners, in order to tailor trajectories accordingly. Working in a real-life context with a high complexity level makes learners easily susceptible to drowning in all the possible areas to address. Insight into the learners' existing strengths and

lacunas helps to prioritize the competencies to work on and identify strengths that could be leveraged in this process. The framework offered in Table 1 can help to inventory the learners' competency levels. Based on a draft version of this framework, Jongstra, Pauw and McKenney (2016, 2017) developed a self-report questionnaire to identify areas for development. In this questionnaire, learners respond to 61 statements (using a 5-point likert scale) concerning (their own perceptions of) their cross-cutting competencies in relation to the different phases of design research. For example, an item pertaining to flexibility during analysis and exploration is: "I approach problems using different perspectives." The questionnaire and its results can be used to structure discussion of the learners' capacities.

As an example, the conclusion for Lisa, an experienced educational designer, is that she needs to work on her flexibility, because she finds it difficult to remain open minded (as a consultant) in the analysis and exploration phase. She finds her pervious design project experience useful but also distracting as she must resist the tendency to color her perceptions of the current situation by her previous experiences, and she finds it tempting to consider ready-made solutions based on her previous work. The learning trajectory for this person should include learning situations in which this element can be practiced and evaluated.

Guideline 2: Establish clear mission and goal

In light of the research aims and stage, as well as the assessment of existing capacity, it is of importance to identify and prioritize goals for design researcher learning within a feasible time frame. As suggested in the Schanks' goal-based scenarios (Schank, 1993/1994) setting goals and defining a mission is essential in learning-by-doing settings. Design research

settings are complex and rarely clearly structured. To foster learning, clear goals help select learning situations in which the learner can practice and reflect on specific competences. It may be obvious that the goals should be based on the assessment of needs, and that the goals should be formulated using SMART (specific, measurable, assignable, realistic, and time-related) guidelines.

For example, Jim just graduated from an academic master in the educational sciences, and will work with a primary school on a project to design a program to foster children's' computational thinking and programming skills. As a beginning researcher, he only experienced the role of designer during his studies. His mission is to help the project to be successful, but also to become a better educational design researcher and to obtain evidence of that. One of his goals is to be able to lead a group of teachers and designers to come up with designs that they all believe in, and will later be able to evaluate based on objective criteria (phase: design and construction, role: designer, competence: social competence).

Guideline 3: Define assessment criteria

The 4CID-model van Van Merrienboer (1997) describes how performance criteria and standards can best be designed in order to make proper judgments of learning and formulate further learning needs. To start, a hierarchy is needed to define the constituent skills on which the competency assessment should take place. Given the constituent skills, the criteria and standards should then be explicated. Going a step further, a rubric can be designed to get more insight into if and how learners meet the standards. In a study by Kicken, Brand-Gruwel, van Merrienboer and Slot (2009a), performance standards and criteria were defined for a vocational

educational program, and used to shape an electronic development portfolio that helped learners assess current skills and plan subsequent learning tasks.

For example, part of the researchers' role in the analysis and exploration phase is doing a literature review. Literature review can be further broken down in constituent skills: 1) Define the research question, 2) Search for information, 3) Selection and scanning of relevant and reliable sources, 4) Processing information, 5) Presenting the information in a review (e.g. Brand-Gruwel, Wopereis, & Vermetten, 2005). Also, these constituent skills can be further divided and criteria can be formulated. Helvoort, Brand-Gruwel, Huysman, and Sjoer (2017) constructed a rubric for this skill, and a criterion and standard are for instance: The learner used appropriate keyword when searching for sourcing and information. The standard for proper behavior is formulates as: The learner uses *specific* search terms that are *relevant* for the topic, uses *synonyms* and *operators* and also takes *languages* into account.

Guideline 4: Create learning opportunities

Situated learning and learning by doing in the creation of appropriate learning opportunities is of importance. The 4CID-model (van Merriënboer, 1997) argues that the design of learning tasks from simple to complex and situated in an authentic setting with embedded support fits learning best, especially when aspects such as cognitive load are taken into account. Four possible task solutions could be relevant and are described here: example-based learning, completion problems, emphasis manipulation and part task solutions. Using these solutions in a variety of authentic settings will facilitate the transfer of the learned competencies.

Example-based learning finds support in disciplines such as Bandura's *social learning theory* (Bandura, 1977). From this perspective, skills learning takes place by observing an expert executing the skill. Observational learning can be facilitated by giving learners modeling examples, showing a model performing the skill while thinking out-loud and providing important insight into the thought-processes and decision making that otherwise remains covert. Studies reveal that modelling examples are effective to foster learning of complex skills (Van Gog, Paas, & van Merriënboer, 2008). When learning to conduct educational design research, observing experts and analyzing and reflecting on their behaviors (for instance when leading design sessions) using the framework provided in this chapter give good opportunities for identifying aspects of performance and possibly discussing them afterwards.

Completion problems are problems in which the learner is provided with a given state and a partial solution. After studying the partial solution, the learner completes the remaining steps to solve the problem. This method stimulates active processing of the given solution steps because they give the essential information the learner needs before being able to continue. For example, in the role of consultant, a learner can get information and study the given state concerning the problem definition and also observe a mentor in the first meeting and analyze the process. Given the current state, the learner can prepare the next step in the process and lead the next session with the stakeholder and focus on, for instance, on being emphatic and using social competence to create room in a discussion and encourage all stakeholders to share their own ideas.

Emphasis manipulation means that, during learning in a complex process, the focus can be directed to learning specific competence (Frerejean,

Van Strien, Kirschner, & Brand-Gruwel 2016). The cognitive load can be too high if a learner should focus on all competences at the same time. Focusing on a specific competence also means that after performing, using the assessment criteria, the evaluation and reflection will lead to formulation of further learning needs. For example, when in the role of consultant, the learners' focus may be on empathy while leading a session with the stakeholders. After the session, the learner and mentor(s) and possibly peers can evaluate if the learner gave all participants room to reflect on ideas and was not too directive. Also, other criteria should be evaluated. A clear overview of the competences and assessment criteria is a must when using emphasis manipulation in supporting learners to become educational design researchers.

Part tasks can be designed when specific aspects with more a routine character are at stake (Van Merriënboer, 1997). For instance, when in a researcher's role working on a literature review, one should know how to search in databases. This can be practiced in isolation. It is of importance to identify these aspects and design these part tasks and give the learners just in time information concerning the procedures that should be used.

Guideline 5: Create awareness

Learners and mentors need to be aware of what doing educational design research encompasses. They need to build mental models of the different phases of the process, the roles and competencies, analyzing them in the domain and representing them in mental models. The models concern the regularities, cognitive strategies, and problem-solving approaches when conducting educational design research. The framework presented in Table 1

can be starting point to think about approaches that help the learner to solve problems during the process.

For instance, what is an approach when, in the role of designer in the design phase, the members of the design group focusing on developing students' computational thinking skills have divergent ideas about what would be effective instructional measures for teaching computational thinking skills? A strategy could be to make an overview of the ideas and to conduct a literature review to gather evidence for the different ideas to underpin the various choices. Digital tools (e.g. mind mapping software) can help to generate and structure ideas. Creating the awareness concerning different approaches and strategies enables learners (and their mentors) to make well-grounded decisions about how to handle upcoming situations and reduce ad hoc decisions in unpredictable situations.

Guideline 6: Stimulate self-directed learning

In situated learning, especially with adults, the importance of self-directed learning and define one's own learning needs has long been recognized (Knowles, 1975). Giving learners the opportunity to direct their own learning can have a positive effect on the learning results, because they can adapt the learning to their particular needs. Directing one's own learning and creating tailored learning trajectories makes learning more personally relevant, thereby fostering motivation. When learners experience responsibility for their own learning it offers the opportunity to develop self-directed learning skills and to prepare for lifelong learning as independent learners.

Well-functioning design research teams have a natural tendency to engage in adaptive management, "an iterative process that involves

stakeholders who learn through a cyclical process of setting objectives, planning, taking action, monitoring, and reflection on the outcomes, learning and taking action again" (Cundill, Cumming, Biggs & Fabricius, 2012). This kind of learning is heavily focused on the task, and seems worth articulating. At the same time, researchers maybe so embroiled in the task facing them, that attending to their own personal learning (e.g. roles and competencies) might feel like an unnecessary luxury. Good mentors as well as institutional routines (e.g. the common requirement of a PhD personal development plan) can stimulate the pursuit and monitoring of personal learning goals.

Guideline 7: Give support and feedback

During the learning process, support and feedback are essential to help learners focus on their own learning needs and to meet their learning goals. Design researcher support can take many forms, including advice (generic or tailored), tools (e.g. templates, checklists), and examples (procedural or conceptual). Feedback includes corrective or affirming comments about past behavior, and works well with feedforward, i.e. corrective or affirming comments about future behavior. While basic process support for conducting educational design research is available (e.g. McKenney & Reeves, 2012), design researchers often rely on mentors, coaches and peers for helping translate and adapt general ideas to their specific settings, or for feedback on their personal learning and performance.

One effective way of support is using reflective dialogues (Kicken, Brand-Gruwel, Van Merriënboer, & Slot, 2009b). By asking reflective questions such as "How do you think the meeting went with regard to learning goals you focused on?", "Do you think you can simultaneously work on these three goals?" or "How long do you expect it to take you to reach this

goal?" the mentor can help the learner to reflect on the performance, define points of improvements, and formulate realistic goals. Moreover, reflective dialogue gives the mentor and learner a better insight in the learner's level of self-directed learning skills.

To sum up, to support learners to become educational design researchers that can deal with a wide variety of complex situations during the process, multiple instructional measures can be taken. These measures are highlighted in the above-mentioned guidelines. The framework offered in Table 1 can provide structure for using these guidelines. Namely, it provides starting points for investigating and monitoring design researcher learning.

Concluding Remarks

We have argued for the development of design researchers with multiple skill sets. We have highlighted the importance of three roles and four kinds of competencies. And we have discussed research-based ways to support the development of those competencies. We have tackled this work from the perspective of conducting educational design research together with practitioners. We conclude with reflections on the role of context, individual design researcher expertise, and skills for modern researchers in general.

As described previously, conducting educational design research constitutes a complex task. The complexity stems from the many different and connected aspects that bear consideration (often simultaneously), and require multiple skill sets. Additionally, the task is complex because it takes place in exciting, dynamic, and highly diverse ecologies of educational practice. While the competencies and roles described here are common

across design research settings, each context brings its own considerations, including affordances and constraints. As a result, even when similar goals are articulated (e.g. increasing physics teacher capacity to make effective use of online modeling tools) their specific manifestations will most certainly vary due to contextual differences, for example in stakeholder values, available resources, or leadership priorities. While specific settings have some influence on how design researchers (can) fulfill their roles and competencies, this process is also shaped by their own vision and judgment, two important aspects of expertise.

To some extent, design approaches appear to be a matter of personal preference or conviction (Visscher-Voerman & Gustafson, 2004). Yet professional orientations, and certainly one's expertise, are powerfully shaped by one's own experiences. Like most complex tasks, design research relies on both adaptive and routine expertise. Adaptive expertise is used to complete tasks which are novel (for those involved). For example, creating an innovative lesson series using online labs for inquiry learning to foster deep understanding of diffusion and osmosis would require a design researcher's adaptive expertise if such work has not been undertaken previously. In contrast, routine expertise is used to create additional instances of tasks previously undertaken. This would be used if a designer researcher were to revise the aforementioned lesson series, or create a second lesson series based on the same principles of inquiry learning but this time for Mendelian inheritance. This distinction seems important, given that scholarship has emphasized key differences in how each type of expertise develops (Lin, Schwartz & Bransford, 2007; Bransford et al. 2010). Since both adaptive and routine expertise are required for design research, it seems important to

understand and provide adequate opportunities for (supporting) the development of each.

Finally, it seems important to point out that, while the skills mentioned here develop through and later also serve interaction with practitioners, they are increasingly crucial skills for all modern researchers. Writing in the *Journal of Investigative Surgery*, Toledo-Pereyra (2012) suggests the following 10 qualities of a good researcher: interest, motivation, inquisitiveness, commitment, sacrifice, excelling, knowledge, recognition, scholarly approach, and integration. Through extensive international research, Deloitte and Apec (2010) identified three sets of competencies required by researchers now and in the future: scientific competencies (scientific knowledge, ability to learn and adapt, ability to formulate a research issue, capacity for analysis and grasp of sophisticated technology tools, ability to work in an interdisciplinary environment, and ability to incorporate existing knowledge), project and team management skills (ability to work in a team, ability to develop a network, communication skills, ability to asses, language skills, business culture and management skills, project management skills, ability to manage and steer teams, awareness of the pertinence of the research and its impact on the environment), and personal aptitudes/interpersonal skills (creativity, open-minded approach, motivation/involvement, adaptability, ability to self-asses). Clearly, the foundational and cross-cutting competencies described here (empathy, orchestration, flexibility, and social competence) align well with existing literature on researcher competencies.

Thus, well-prepared researchers have much more than robust methodological skill sets. As Hostetler (2012, p. 16) indicates,

> "The question of what counts as good education research… [is too often] conceived principally as a methodological question rather than an ethical one. Good education research is a matter not only of sound procedures but also of beneficial aims and results; our ultimate aim as researchers and educators is to serve people's well-being."

Design research has great potential to contribute to educational research in general (Anderson & Shattuck, 2012), and to the field of learning and instruction, specifically (Gravemeijer & Cobb, 2006). Because design research activities themselves simultaneously contribute to improving theoretical understanding and design practices of professionals, the researcher-practitioner learning through design research might best be characterized using Levin's (2013) notion of knowledge mobilization – stressing the interactive, social and gradual nature of the bilateral connections between research and practice. Yet this potential contribution can only be realized when investigator skills include those of the consultant, designer and researcher. Currently, few (graduate) programs support researcher learning in the domains described above, and little explicit attention is given to the cross-cutting and foundational competencies described. It may be that traditional research institutions have undervalued the contributions these roles have to make to both research and development in education (Burkhardt & Schoenfeld, 2003), but more modern ones have begun to emphasize, stimulate and reward researcher attention to the co-creation, uptake, and use of knowledge. This chapter offers considerations for targeting such efforts, and offers specific examples with regard to educational technology design research.

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Biographical Sketch:

Prof. dr. Susan McKenney co-leads ELAN, the Department of Teacher Professional Development within the Faculty of Behavioral and Management Sciences at the University of Twente and is visiting professor in the Learning Sciences & Policy Group at the University of Pittsburgh. Her research focuses on understanding and facilitating the interplay between curriculum development and teacher professional development, and often emphasizes the supportive role of

technology in these processes. As such, she also studies processes of design that can be applied in the field of education, and synergetic research-practice interactions. She is committed to exploring how educational research can serve the development of scientific understanding while also developing sustainable solutions to real problems in educational practice. Since design-based (implementation) research lends itself to these dual aims, her writing and teaching often provide ideas about how to conduct this exciting form of inquiry. In addition to authoring numerous articles, she co-edited the book, *Educational Design Research* and, together with Tom Reeves, wrote the book, *Conducting Educational Design Research*. She has served as guest editor of special issues in *Instructional Science, European Journal of Education, Australasian Journal of Educational Technology, Pedagogische Studiën,* and *Technology, Pedagogy and Education.* She is currently associate editor for the *Journal of the Learning Sciences* and has authored over 100 peer-reviewed publications.

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Prof. dr. Saskia Brand-Gruwel is dean of the faculty Psychology and educational Sciences of the Open University of the Netherlands. Her research, positioned in the Welten Institute, centre of learning, teaching and technology, focuses on information literacy, self-regulated learning and instructional design to foster these higher-order skills with a special interest on the use of technology in education. She studies the cognitive processes involved in the mentioned skills and the effects of instructional measures to support the skill acquisition in the interplay of more experimental research and design-based research. In addition to authoring numerous articles, she was guest editor for different special issues for the journals *Learning and Instruction, Computers in Human Behavior* and *Journal of Computer*

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