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DEVELOPMENT ARTICLE

Educational design research: grappling with methodological fit

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Abstract
Educational Design Research (EDR) employs a diverse range of methods to study learning, teaching, design, and technology—and new ones are shared in this special issue. We contend that a focus on methods inherently requires examination of the questions they are used to answer and the ways in which the resulting findings advance scientific understanding. Specifically, this article focuses on obtaining and guarding methodological fit in EDR. It describes three main orientations to research inherent in EDR trajectories (research for, on, and through interventions), the kinds of questions we ask in each, how our methods evolve accordingly, and challenges to alignment that are often encountered along the way. Thereafter, it offers examples of the three orientations in two different doctoral studies on innovative educational technologies, each of which demonstrates methodological fit as well as relevance for practice despite the phase-related shifts in focus, questions, and methods. The article concludes with a framework for assessing methodological fit both within and across the three orientations to EDR in two studies, along with broader recommendations for conducting EDR in the field of educational technology.

Keywords Educational design research · Design-based research · Learning technologies · Change and innovation · Design and development · Intervention and evaluation

Introduction

Methodological fit refers to the internal consistency among elements of a research project, including the alignment between the research questions, prior work, research design, and contribution to the literature (Edmondson & McManus, 2007). Achieving strong methodological fit is challenging in any case, because it requires a deep understanding of methodological options, sound insight into the affordances and limitations of each, and a flexible repertoire of ways to employ them. The challenge is even

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greater when it comes to research that is conducted in, for, and with educational practice. This is because timelines, sampling, data collection, logistics and even the focal areas of interest are matters of joint consideration, as opposed to resting solely in the hands of the researcher. Such is the case with Educational Design Research (EDR), "a genre of research in which the iterative development of solutions to practical and complex educational problems also provide the context for empirical investigation, which yields theoretical understanding that can inform the work of others" (McKenney & Reeves, 2019, p. 6). In EDR, trade-off decisions are constantly being made, for example between methods which are: conceptually robust but ecologically invalid; unobtrusive yet impractical for reliable analysis; or ideal but unavailable during the data collection window of opportunity. This article focuses on guarding methodological fit for purpose within and across differing phases of EDR trajectories.

The term, EDR, is used here as an inclusive descriptor which encompasses all approaches that strive toward the dual goals of advancing scientific understanding through the development of interventions to enrich educational practice. Many approaches common to the field of educational technology fall under the descriptor of EDR. Bakker (2018) provides an insightful review of the history and subtle variations in names for this kind of work, such as design experiments (Brown, 1992; Cobb et al., 2003; Collins et al., 2004), design-based research (Barab, 2022; Hoadley, 2004), design-based implementation research (Penuel, 2014), formative interventions (Engestrom, 2011), and educational design research (McKenney & Reeves, 2019; Plomp & Nieveen, 2013; Van den Akker et al, 2006). These twin goals are also shared by design science research, which is well known in the fields of management science (e.g. van Aken, 2004) and information science (e.g. Hevner, 2007). Because design science research is conducted with the aim of organizational learning and improvement, it could be viewed as part of the EDR family.

While individual trajectories always differ, EDR projects invariably yield outcomes for both theory and practice. The practical results can include educational products (e.g. a multiuser virtual learning game), processes (e.g. a strategy for scaffolding student learning in flipped classrooms), programs (e.g. a series of workshops intended to help teachers develop more effective online questioning strategies), or policies (e.g. minimum 1:1 time for the on-site mentoring of interns). The theoretical understanding resulting from this kind of work can be used to describe, explain, predict, or manipulate educational phenomena. Further, it has long been understood that most projects evolve through multiple iterations of three core phases. Early on, analysis of the existing situation is undertaken to inform the design and enactment of an intervention, the outcomes of which are also studied (Bannan-Ritland, 2003; Ejersbo et al., 2008; Reeves, 2006; van den Akker, 1999). The intervention is iteratively refined through multiple cycles of empirical tuning (Edelson, 2002). Often, the professional development of those participating in the study (practitioners and researchers alike), is a documented by-product of the overall EDR process (Becker & Jacobsen, 2022).

This conceptual contribution describes the kinds of issues we attend to in research using EDR and how methodological fit is attuned accordingly. It begins with existing methodological considerations related to EDR, with emphasis on projects involving educational technology. Next, it discusses how and why the focus of inquiry shifts over time and offers a naturalistic account of factors that shape methodological choices. Next, we present the two examples, which illustrate and further unpack the methodological issues raised. The paper concludes with guidelines for assessing methodological fit and problems to avoid.

About methodological fit in EDR

Existing methodological discussions

As an orientation to disciplined inquiry instead of a prescribed methodology, EDR uses existing qualitative, quantitative, or mixed methods for developing theoretical understanding, as well as the related criteria for rigor that have been established by the scientific community. Further, EDR leverages existing practices from the fields of design, sociology, and education to shape and understand participation and engagement. In addressing two critiques of design research, that it lacks methodological rigor and clear standards, and that it cannot satisfy claims of simultaneous design evaluation and theory building, Sandoval (2014) proposed conjecture mapping as a method for articulating both design and theoretical ideas embodied in a learning environment. "A conjecture map reflects a research team's commitment to what it sees as the most important design problem to be solved and its initial ideas of the important questions to ask" (p. 20). With regards to our emphasis on asking precise questions matched with carefully selected methods, Sandoval (2014) contends that "the success of any design endeavor requires making some commitment to articulating what desired outcomes will look like and how they might be observed or measured" (pp. 23–24).

Identifying problems to tackle in educational technology (i.e. gaps between the existing and desired situations) that are amendable to educational design research (EDR) involves finding real-world challenges that are worthy of investigation and capable of being solved through the EDR process. When even an obvious or serious problem is raised, verification in both literature and practice is necessary to ascertain if it is, indeed, legitimate, researchable, and research-worthy. From the theoretical perspective, the problem is worth studying if doing so would address a clear gap in existing literature (legitimate); if existing methods will allow it to be studied well enough to warrant the effort (researchable); and if the work could contribute to theory development or scientific understanding related to a widely held, as opposed to idiosyncratic, concern (research-worthy). From the practical perspective, the problem is worth solving if the real problem is identified, as opposed to a symptom (legitimate); if it can be identified in accessible contexts (researchable); and if it is severe enough that stakeholders care to invest in solving it (research-worthy). The discussion of EDR presented here examines the process as a whole and with particular attention to its scientific contributions.

We contend that the methodological robustness of EDR is evaluated using existing criteria for qualitative, quantitative and mixed-methods studies. The question of methodological fit is one that rears its head many times throughout various iterations of a single EDR project. This is because questions naturally change during a study, in line with the phases described previously. As described next, methodological pluralism is typically required to accommodate this emergent form of responsive inquiry and iterative design.

Orientations throughout EDR trajectories

Because it is an approach and not a method, EDR can be used flexibly to address a wide range of questions, problems, and phenomena in educational technology. In fact, within single trajectories, it is common for individual cycles of inquiry (i.e., analysis, design, evaluation) to pursue related but different goals in terms of developing theoretical

understanding, commensurate with the goals of the phase at hand. Across the wide variety of intellectual domains upon which educational design research may focus, several basic orientations may be identified. Individual sub-studies conducted either for, on, or through interventions can yield useful scientific understanding. Further, across these orientations, the synthesis of findings often takes place. The three research orientations are depicted in Fig. 1. We acknowledge that the progression through these orientations is rarely linear and can vary greatly, depending on the goals of the study and related prior work, both in the target setting and in literature.

Research for interventions

Shown with a solid line, research *for* interventions yields information which contributes to theoretical understanding and serves the work of others, while also providing important inputs for design work. At this stage, the intervention is unknown and the focus is on understanding the challenge to be tackled, the complexities of the context in which the challenges are situated, and the perspectives of the stakeholders. A research question from this orientation may be, "How do existing human, material and structural resources foster or hinder school-based curriculum development in rural Iceland?" Answers to this question can be valuable in their own right as well as informative for intervention design.

Research on interventions

Shown with a dashed line, research that focuses primarily *on* interventions strives to generate knowledge about characteristics and functions of particular types of interventions. It views the intervention as one manifestation of a particular phenomenon (e.g. MOOCs, MUVEs, teacher dashboards) and inquiry focuses on the qualities of the intervention as a means to meet certain learning goals. Research conducted on interventions foregrounds their design, and uses information about how the intervention works, with whom, under what conditions, and with what results to refine its characteristics. In a study of students' learning while building digital video games in middle school, Lambert and Jacobsen (2020) asked, "In what ways do teachers' design of instruction and learning tasks need to shift when designing and building digital video games to intellectually engage students in deep learning of curriculum content and to develop twenty-first century competencies in school?" Answers to such questions can serve the designs of others as well as of those in the specific research context in which this study took place.

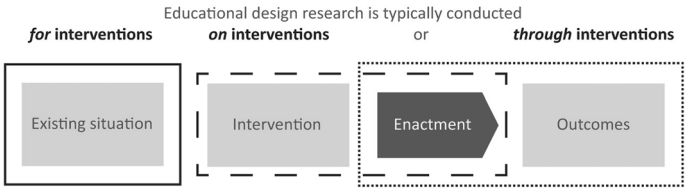

Fig. 1 Orientations in educational design studies (adapted from McKenney & Reeves, 2019)

Research through interventions

Both research on and through interventions typically attend to enactment processes. But research conducted *through* interventions, shown by the dotted line, is focused on understanding the responses the intervention engenders. Unraveling the multifaceted interaction between intervention and context is taken into consideration, if not an explicit focus of the research. Here, the intervention may be viewed as the means through which deeper insight can be gained into certain phenomena relating to teaching and learning in authentic settings. In evaluating the design and implementation of a massive open online course for supervisory development from this orientation, Jacobsen et al (2021) posed the research question, "In what ways does the quality graduate supervision MOOC support and benefit faculty in the ongoing development of graduate supervision practices?" Answers to this question inform others as well as stakeholders in the target setting.

Synthesis across three orientations

Finally, the light line surrounding all three boxes represents the synthesis of findings from *across* an entire EDR trajectory. It is common for certain issues to be revisited from multiple perspectives in different phases of inquiry, and a well-designed EDR trajectory affords opportunities to triangulate on them by comparing, contrasting, or combining related data or insights over time. For example, across four sub-studies related to teacher video coaching, van der Linden (2022) synthesized findings from: the first three sub-studies to conceptualize teacher reflection in video coaching settings; the last three sub-studies to articulate support for improving teacher reflection in video coaching settings; and findings from the last two studies to reify that support in the form of specific tools for improving teacher reflection in video coaching.

Methodological alignment in three orientations across EDR trajectories

To elaborate on methodological alignment, several research goals (descriptive, explanatory, predictive, prescriptive) along with initial implications for designing questions and methods in the response to each of the three orientations and overall synthesis in EDR are described in Table 1. With this conceptual description, we aim to support researchers in approaching the challenge of setting up a coherent educational design research proposal with robust methods, and what can make it feasible to remain responsive to what the data surfaces (what you find out) along the way. We elaborate further on the implications for questions as well as the inherent tension in questions that are nimble (open enough to operationalize in each phase) and precise (can be answered well) in our synthesis of two doctoral works.

Examples of methodological fit in educational technology EDR

To unpack methodological fit in the three orientations and synthesis described above even further, we draw upon two doctoral studies that used an EDR approach to investigate change and innovation with different learners in two different contexts. In both cases,

Table 1 EDR orientation focus and research goals with implications for study design

Orientation focus	Orientation goals	Implications for questions	Implications for methods
Research for interventions	Descriptive and explanatory understanding of the existing situation	Focus on problem, context, learners, stakeholders, technologies	Review of existing research and practice; leans to qualitative, also mixed methods; may be ethnographic, field study, systematic review
Research on interventions	Descriptive, explanatory, and predictive understanding of characteristics (and enactment) of solutions	Focus on intervention features and implementation considerations (e.g., for real-world impact in the given timeframe)	Often mixed methods
Research through interventions	Descriptive, explanatory, predictive and prescriptive understanding of intervention (enactment and) outcomes	Situate the study in context; Clarify significance for a broader audience; case-to-case generalization	Multiple methods, prioritizing (Quasi-) experimental, showing pre/post measures, often combined with qualitative data
Synthesis across orientations	Synthesize findings from all phases or substudies to yield new scientific understanding	Focus on addressing gap(s), in the literature; in target settings where research-practice connections and possibilities for collaboration are in place (context)	Broad and deep methodological repertoire; Pre-planning/anticipate impacts/outputs from each cycle, responsive planning to emergent study events; plan for multiple papers by phase or question or study type; know the audience for the reporting; identify target publication outlets at the start of the writing process

the context was core to each research story. Also in both cases, the researchers focused on understanding the complexity of real-world practice in collaboration with practitioners, articulated desired outcomes and measures (Sandoval, 2014), enacted flexible design and revision, and engaged participants as co-designers in the creation, and evaluation, of the educational interventions (Barab & Squire, 2004). Each study demonstrates how it is possible to maintain theoretical and methodological rigor as well as relevance for practice while shifting focus and questions along with the different phases of EDR. One study is a manuscript-based dissertation on a problem of practice in initial teacher education (Coninck, 2019) and the other a long-form dissertation on a problem of practice in health education (Meyers, 2017). Both researchers employed precisely defined research questions for each phase and cycle of the research and used diverse methods to engage in multiple cycles of optimization (Table 2), thus addressing the single cycle optimization shortcoming of DBR identified by Zheng (2015) and mentioned in the call for papers in this special issue.

Case 1: expanding the pedagogical expertise of infection control professionals

Meyers' (2017) research takes place in the field of health education. Infection Prevention and Control (IPAC) programs are charged with educating healthcare workers (HCWs) to prevent the spread of microorganisms, viruses, and infections. HCWs include individuals who provide direct care to patients and those who have contact with care environments in various sectors. In her doctoral study, Meyers (2017) focused on building IPAC educational practice by exploring how to change Infection and Control Professionals' (ICPs') understanding of education, influence development of their identity as educators, and to develop their pedagogical expertise to improve ways in which they teach HCWs. To achieve these changes, ICPs were invited to participate in an innovative, research informed, interventionist professional development experience that could be characterized as a community of learning and was situated in the context of the ICPs' workplace practice. The ICPs' learning experiences were mediated through their active engagement in collaborative teaching and learning activities along with mentored hands-on instructional design and development work as they created a flipped online learning experience to use with HCWs. In her multi-phased, mixed-methods educational design research, Meyers (2017) incorporated critical analysis of the literature, surveys, interviews, focus groups, structured observations, and journaling. As shown in Fig. 2, the study began with analysis and exploration, which informed multiple iterations of intervention development, implementation, evaluation and reflection, and concluded with a final cycle of evaluation and reflection.

Research for interventions

The initial phase of Meyers' (2017) study focused on developing understanding of the pedagogical problem, the healthcare education context, and ICP educational practice. The research questions demonstrate how investigation can be shaped to inform the design of an intervention as well as the work of others (Table 2). A critical analysis of 122 studies of IPAC educational interventions expanded understanding of the problem space (Meyers et al., 2018a). An online survey, a focus group interview, and field observations of ICP education sessions were the mixed methods used to collect data from the field. Together, the data sources yielded a description of the existing situation and provided new insights on challenges that ICPs face on a continuing basis as they strive to improve the IPAC practices of nurses and other HCWs (Meyers et al., 2018a). Namely, the limited impact of ICP

Table 2 Research questions and methodological alignment by research orientation in the examples

Orientation	Meyers (2017)		De Coninck (2019)	
	Questions	Study design	Questions	Study design
Research for interventions	(1) What are the current educational practices of ICPs? (2) What challenges do ICPs have regarding developing and providing education to HCWs?	Critical analysis and exploration of research literature Mixed methods evaluation of existing education sessions (online survey, interviews, field observations)	(1) How can we conceptualize student teachers' parent-teacher communication competences? (2) How can we measure student teachers' parent-teacher communication competences?	Critical analysis and exploration of research literature Mixed methods evaluation of current educational contexts (document analysis, field research) Instrument development studies: (1) Development and testing of video-based instrument to assess PTCC; (2) Development and testing of tool to measure student teachers' self-efficacy with PTCC
Research on interventions	(1) What theoretical frameworks and principles are useful for developing and informing ICP educational professional development and ICP educational practices? (2) What design elements are useful to support effective ICP use of an innovative educational intervention using technology to teach HCWs and promote ICP pedagogical professional development?	Review of research literature Development of theory and practice informed design principles Development of ICP professional development intervention and framework Mixed methods intervention study (online survey, focus group interviews, field observations and researcher journal)	How do we develop student teachers' parent-teacher communication competences via clinical simulations?	Review of research literature Development of framework featuring four design principles Development of two prototypes of simulation-based learning environments (face-to-face, online) Formative evaluation of prototypes

Table 2 (continued)

Orientation	Meyers (2017)		De Coninck (2019)	
	Questions	Study design	Questions	Study design
Research through interventions	How does participation in the development of an innovative research-informed educational intervention for HCWs promote ICP educational professional development and influence practice?	Mixed methods intervention study (focus group interviews, recorded discussions, workshop materials and products, short questionnaires, and a researcher journal) Four cycles of analysis, with each informing subsequent actions and refinements	Cycle one: How and why does participation in face-to-face clinical simulations affect student teachers' PTCC-related: (1) self-efficacy beliefs, (2) situation-specific skills, and (3) performance? Cycle two: How and why does participation in face-to-face or online clinical simulations change student teachers' PTCC-related: (1) self-efficacy beliefs, (2) situation-specific skills, and (3) relationships between perception, interpretation, and decision-making skills	Two quasi-experimental intervention studies using mixed methods (Self-efficacy survey, training and reflection videos, pre-test/post-test design)
Synthesis across orientations	How can ICPs' understanding of education be changed to influence their development of identities as educators and develop pedagogical expertise to improve their teaching of HCWs? Why is EDR a useful methodological approach for influencing change in the field of IPAC and the context of the healthcare workplace?	Educational design research with one macro cycle comprised of three phases, yielding theoretical and practical insights and outcomes from each micro and/or meso cycle, which informed the subsequent cycles and phases Integration of data, evaluation, reflection Researcher journals a valuable source of data within and across phases	How can parent-teacher communication competency (PTCC) be developed during initial teacher preparation? Why is EDR a useful methodology to influence change in PTCC during initial teacher preparation?	Educational design research evolved through several phases and employed a range of research designs within each phase, including two instrument development studies, a design study, and two intervention studies

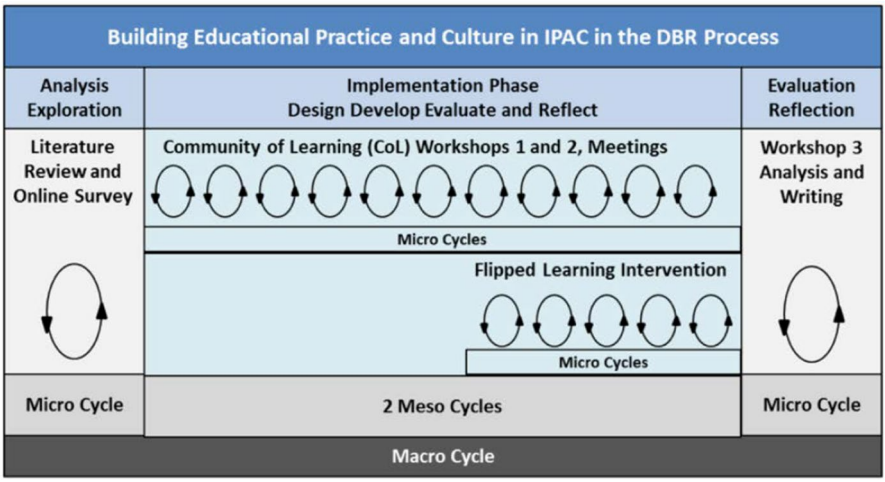

Fig. 2 Micro, meso and macro cycles of research in Meyers (2017, p. 68, reprinted with permission)

teaching on changing HCW practice is problematic. Despite ongoing consultation and education by ICPs, HCW adherence to recommended IPAC practices can vary. In part, the problem is connected to a shortage of pedagogical expertise by ICPs, which is related to a constrained conceptualization of education and learning in health care teaching. This, in turn, contributes to the methodological, conceptual, and epistemological limitations associated with many IPAC educational interventions. A second challenge stems from the research used to study ICP educational interventions, which typically prioritizes the randomized control trial and pre-post measurement of content retention over in-depth investigation of learner experiences and contexts. While such studies can be useful for determining if ICP educational interventions have effects, they rarely offer insight into how or why. As a result, ICPs are often not well-prepared for their teaching role, and opportunities for high-quality educational professional development are limited. Relying on prepared visuals and information delivery teaching approaches, ICPs are frustrated with poor results and then disengage from educational efforts.

This phase yielded understanding of gaps in IPAC intervention research (Meyers et al., 2018a) and problems in ICP educational practices, along with the theoretical, conceptual, and methodological challenges to be addressed (Meyers et al., 2018c). It also brought into focus a research-worthy opportunity to be leveraged, namely that ICPs were primed for educational professional development that encompassed contemporary learning theories and teaching with technology strategies. From a practical perspective, this phase of study explained how ICPs require support in making shifts in their teaching and learning practices. Attention needed to be given to modifying how ICPs work with disciplinary knowledge, embrace educational technologies, and design educational environments for learning.

Research on interventions

The design and implementation phase focused on creation of the intervention, a professional development framework and program (Meyers et al., 2018b). The goal of this phase was to develop ICP pedagogical expertise and ICP educational practices through

engagement in a learning community and the co-development of a research informed education intervention focused on improving their pedagogical practices and HCWs learning outcomes. Two research questions focused on the design and development of the intervention (Table 2). Theory and practice were woven together to inform the ongoing design and enactment of the community of learning. Activity theory, the zone of proximal development, and situated learning, as well as principles from collaborative learning, knowledge building, cognitive apprenticeship and community of inquiry literature informed the constructivist philosophical and conceptual framework underpinning the design and development of the ICP community of learning activities and the professional development experience that resulted from this phase of the study (Meyers et al, 2019). Data collection occurred over 19 months and included an online survey, focus group interviews, field observations and researcher journals. Quantitative survey data was analyzed descriptively and Chi-square tests; qualitative data was analyzed using an iterative, systematic thematic analysis (Meyers et al., 2018b).

Theoretical output from this phase was descriptive local theory regarding IPC educational practice and strategies that combined to facilitate shifts and new development in said practice (e.g., development of identity as educator, pedagogical knowledge, and lexicon). Given the complexity of EDR studies, it is important to maintain certain themes and stories to capture and synthesize the multifaceted data that might otherwise overwhelm researchers pursuing this type of systematic inquiry. For example, Meyers captured an enduring theme of the conflict that ICPs experience between their identify as health care experts and their role and emerging identities as educators (Meyers et al., 2018c). From a practical perspective, this phase of research informed the design of a professional development model and program, the development of online teaching and learning resources by ICPs for ICPs, the creation of an online (flipped) teaching/learning module, and the installation and utilization of a software platform to design e-learning. Drawing on contemporary constructivist concepts and principles, this phase resulted in the creation of an innovative design framework for sustained educational professional development of ICPs.

Research through interventions

This phase focused on the enactment of the intervention and especially on evaluating its outcomes (Table 2). In addition to assessing the program for influence on ICP professional development, there was also interest in exploring the implications of this case for influencing educational practice in healthcare more broadly. Here, the Community of Learning (CoL) was the core interventionist strategy to scaffold ICPs in designing and developing a flipped learning experience to use in their teaching with HCWs. Multiple types of data were collected to document the professional development experience systematically and comprehensively as the researcher and ICPs interacted and engaged in the community of learning. Methods included focus group interviews, recorded discussions, workshop materials and products, short questionnaires, and a researcher journal. The researcher journals kept throughout the study were a valuable source of data across phases, especially given that the researcher's role in the EDR process. In addition to using multiple sources of data, external audits and member checking were used to enhance trustworthiness and credibility of the research (Meyers et al, 2019). Through four cycles of analysis, it was concluded that the program had successfully changed ICPs educational understanding and practice by building their pedagogical expertise and developing their identity as educators through the collaborative development of knowledge, language, and experiences with which to reflect

on and explore their pedagogical practices. In addition, this study demonstrated the value of using EDR to explore teaching and learning in the context of healthcare workplace settings where the focus is on the production and delivery of activities that actively engage learners and learning rather than creating pre-determined content for instructional delivery.

This phase of the research yielded descriptive, explanatory, and predictive mid-range theory regarding IPC educational professional development, as well as refinements to the design framework for professional development in health education. Practically, it yielded increased educational and research expertise and increased visibility of education within the IPAC program. Further, it increased leadership engagement with IPAC education while also increasing ICPs skill and facility to use software to design an e-learning program.

Case 2: clinical video simulations in teacher education

De Coninck's (2019) educational design research focused on the nature and development of student teachers' competencies with parent-teacher communication through use of clinical simulations as an instructional strategy. Clinical simulations are carefully designed settings that support student teachers' knowledge transfer into professional action by offering "approximations of practice" (De Coninck, 2019). In teacher education, clinical simulations bring representations of authentic and realistic professional interactions, in this case parent-teacher communications, into the learning environment. Here, parent-teacher communication refers to the two-way verbal interactions between parents and teachers to exchange ideas about the development and progress of pupils, often in the context of parent-teacher conferences. The problem was precisely defined and researchable. Namely, there was a failure to develop parent-teacher communication competency (PTCC) during initial teacher preparation. All phases of the research were oriented toward addressing this issue. De Coninck (2019) eventually developed clinical video simulations to promote transfer of student teacher knowledge into professional action via rich and authentic learning which offered opportunities to practice and develop their Parent-Teacher Communication Competency (PTCC). Her study evolved through several phases and employed a range of research designs within each phase, including two instrument development studies, a design study, and two intervention studies.

Research for orientation

At the start of her project, De Coninck focused on gaining a deeper understanding of PTCC and how to measure it (see Table 2). Through multiple iterations, she conducted literature review to conceptualize PTCC. Like other competences, she noted that PTCC performance (observable behavior) is influenced by situation-specific skills (perception, interpretation, decision-making) and that these are influenced by both cognitive and affective factors, including self-efficacy. Once her conceptualization stabilized, she then developed two tools to investigate PTCC. First, she conducted document analysis and field research with teacher educators, student teachers, and beginning teachers to inform the design of a tool to measure student teachers' PTCC. Based on the findings, she developed video-vignettes, instructions, and a coding scheme which, together, formed a video-based instrument to objectively assess PTCC. She then tested the instrument with student teachers ($n = 269$) and determined it to be reliable. Second, she developed a tool to measure student teacher' self-efficacy beliefs regarding PTCC. For this, an existing instrument, was translated and adapted before being tested with 581 student teachers. Exploratory factor analysis

identified a two-factor structure. Confirmatory factor analysis demonstrated stability, and reliability analysis determined internal consistency. Results of the descriptive analyses gave insight into the respondents' self-efficacy beliefs about PTCC.

This phase yielded two main theoretical outcomes, one related to each of the tools described above. First, the PTCC model (De Coninck et al., 2018) describes observable behaviors signifying PTCC, early in the conversation (positive opening, gathering information, sharing information), late in the conversation (reaching agreement, ending on a positive note), and throughout the conversation (accepting emotions, maintaining a positive relationship). This model (which was based on Gartmeier et al., 2011; Walker & Dotger, 2012) provided the foundation for subsequent phases of the study and is useful to others investigating PTCC. Second, the survey work identified factors relevant self-efficacy beliefs regarding PTCC, as well as items operationalizing them. By using the survey, she also obtained baseline measures of student teachers' efficacy beliefs about parent-teacher communication. These outcomes (De Coninck et al., 2018) were useful to De Coninck's project and can also serve the work of others. The practical outcomes from this phase are of course the instruments themselves, i.e. the video-based instrument to assess PTCC and the self-report survey to measure student teachers' self-efficacy beliefs about PTCC. Each of these holds potential value for use in teacher education beyond the local context (Belgium).

Research on orientation

After obtaining insight into the nature of PTCC and the status of student teacher self-efficacy in that regard, De Coninck (2019) set out to design clinical simulation through which student teachers could develop their PTCC. First, she reviewed existing literature on simulation-based learning environments in teacher education. Based on this, she derived a framework featuring four design principles: (1) provide teachers with a structured theoretical background, (2) engage students in a real-world learning context, (3) provide a cyclic process including simulation-based experiences, feedback, and reflection, and (4) engage students in collaborative participation. Next, based on the framework as well as consultation with teacher educators, student teachers, practicing teachers and parents, she created two prototypes of simulation-based learning environments to enhance student teachers' PTCC, one in an online modality and one face-to-face. Both modalities contained 9 case simulations, which were derived from literature (some adapted from Dotger, 2013), analysis of student teacher portfolios, observations of parent-teacher conferences, and interviews with parents, teachers, and teacher educators. The set of cases addresses a variety of topics, and each individual case focuses on a specific dimension of the PTCC model. Student teachers were exposed to all nine cases (three during each training and reflection cycle). Figure 3 illustrates how the design principles were operationalized.

When the prototyping had matured to the point of being ready to pilot, a formative evaluation was undertaken with 323 student teachers who were randomly assigned to work with either the online (n = 233) or face-to-face (n = 99) prototypes. Their experiences and perceptions were captured through a survey which ask for rankings and comments on 16 statements (e.g., "I think the learning environment was realistic" or "I think that the simulations prepared me well for what will be expected from me in my future practice as a teacher").

From a theoretical perspective, this phase of the study yielded the four design principles as well as an example of how they can be manifested in a simulation-based learning environment and insight into how student teachers experienced each modality (De Coninck

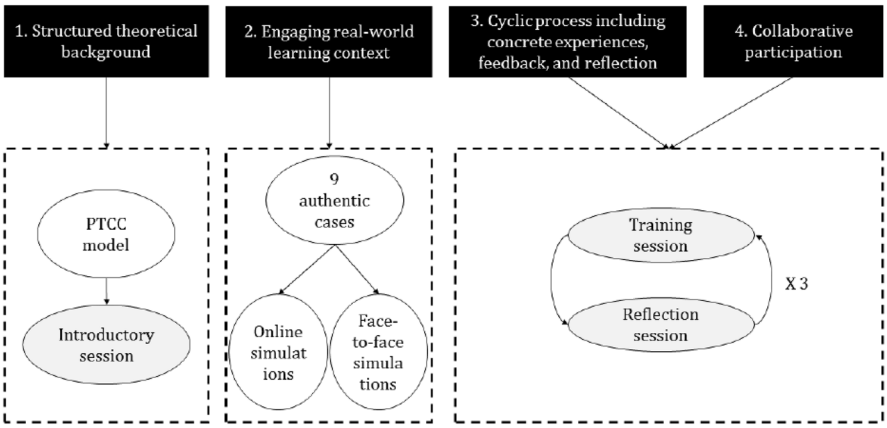

Fig. 3 Operationalization of design principles in de Coninck (2019, reprinted with permission)

et al., 2019, 2020). From a practical perspective, this phase yielded two versions of clinical simulations—online and face-to-face, both of which bridge the theory–practice gap.

Research through orientation

The final phase of De Coninck's trajectory featured two quasi-experimental intervention studies, designed to gain insight into the effectiveness of the simulation-based learning environments. Three questions guided the first summative evaluation during this phase of the study, which focused on the face-to-face simulations. Taken together these questions asked: How does participation in face-to-face clinical simulations affect student teachers' PTCC-related: (1) self-efficacy beliefs, (2) situation-specific skills, and (3) performance? The PTCC self-efficacy survey described previously was used to explore differences before and after the 12-week intervention. The PTCC of student teachers (n = 33) was investigated through analysis of video collected through the three training and reflection sessions. Significant increases were found in self-efficacy beliefs as well as perception and decision-making skills. This was not the case for interpretation skills or performance.

The second summative evaluation compared the impact of each modality on student teacher PTCC. Again, the intervention lasted 12 weeks. Student teachers were randomly assigned to either online (n = 181) or face-to-face (n = 95) conditions. The research questions guiding this cycle focus on comparative (online simulation versus face-to-face) changes in student teachers' (1) self-efficacy beliefs (2) situation-specific skills and (3) relationships between perception, interpretation, and decision-making skills. To investigate and compare the impact of online and face-to-face simulation modalities on the development of student teachers' PTCC, a pre-test/post-test design was used, featuring both the self-efficacy survey and the video-based assessment created in the first phase of the study. Results indicate that student teachers grew more confident of being able to structure a parent-teacher conference and build relationships with parents after participating in either online or face-to-face simulations. Further, student teachers became stronger at perceiving events in a parent-teacher conference, interpreting those perceived events and making decisions about how to act.

The primary theoretical contribution of this phase is the conclusion that both types of simulations were effective instructional strategies to improve student teachers' PTCC (De Coninck et al, 2021), coupled with explanations of why. The primary practical contribution is the routine for implementing the clinical simulations into regular teacher education practice.

Notes on the doctoral research examples

Research on practice in our field benefits from methodological precision (no matter what methods are chosen) and rich accounts so others can judge the value of contribution and make connections to their own contexts for inviting innovation. In their EDR studies, Meyers (2017) and De Coninck (2019) both demonstrate why it is important to ask precise questions from the start of the *research for interventions* phase (Table 1), on existing situations to the *research on interventions* phase, and on the implementation contexts as a core part of the study, and not simply as a place where the designed innovation occurs (Barab, 2022). Continuing in the *research through interventions* phases, the researchers' active co-design processes and inquiry with learners and practitioners in authentic health education and teacher education contexts, and evaluation and iterative design guided by precise questions and informed by close observation, documentation and interpretation of impact in dynamic contexts, both Meyers and De Coninck demonstrate the view of "impact as a shared accomplishment structured by designers of the innovation, but ultimately realized in partnership with the learner in relation to their ecosystem needs and possibilities, is an important shift" (Barab, 2022, p. 190) in EDR. In Table 2, the methodological alignment in questions and study designs for each of three orientations and synthesis in the two examples are summarized.

As presented in Table 2, it may appear as though achieving methodological fit was a straight-forward process in each of these studies. But multiple factors, especially contextual demands, presented a great deal of challenges to the researchers. As such, achieving methodological fit required puzzling, prototyping, and dialogue throughout the trajectory. For example, Meyers worked to analyze and address ICPs diverse professional learning needs, and thus expand system capacity, while simultaneously studying the ICPs' iterative design and enactment of an intervention that disrupted expected practice with HCWs, all of which reflexively informed development of a framework and design principles. Similarly, De Coninck worked to balance the planned and goal-oriented nature of study design to ensure that efforts were on target, while also yielding to factors outside of her control and being alert to potentially powerful meeting points between the two so that implementation and testing of the simulation-based learning environments could be both ecologically valid and sustainable. The remainder of this article reflects on these issues in light of our broader experience base, this including but not limited to the two examples provided.

Guarding methodological fit

Why is this so difficult?

Researchers, practitioners, stakeholders, and learners often engage in reflexive roles in the educational design research process, which can include co-design, collaborative sense-making, and shared influence on social and cultural learning outcomes in knowledge

building communities. With increased spread and reliance on learning technologies and networks across/in diverse learning contexts, educational technology research can and should be understood and practiced as an interdisciplinary research endeavor that draws upon and connects many disciplines. To advance theory and practice, the field will benefit from an expanded methodological toolkit (Barab, 2022) that takes systematic inquiry and design beyond the widespread use of quantitative and descriptive research methods (Bulfin et al., 2014; Reeves & Oh, 2017). Reeves and Lin (2020) argue that "the research we have is not the research we need" and urge the field to shift away from our focus on comparison studies of things (e.g. technologies) and towards embracing useful methods (methodological pluralism) for addressing questions and problems in educational technology.

EDR draws upon precisely crafted research questions and a diverse collection of methods that reflect a commitment to responsively studying learning in naturalistic and dynamic contexts versus controlled lab settings. EDR expands opportunities for legitimate and meaningful inquiry with a sharp focus on the social and cultural dimensions of learning and enhanced study of complex ecosystems of non-formal connected learning across diverse contexts (Prestridge et al., 2021). EDR offers a powerful approach to theory building in our field given the focus on understanding learning in ecologically complex, technology-enhanced environments with the goal of generating robust outcomes that are useful and relevant for practice. EDR offers a pragmatic and flexible research approach to studying cycles of change and innovation in dynamic and authentic contexts that goes beyond descriptive studies in controlled lab settings or comparison studies using technology without consideration of complex human interactions and contexts. Educational design researchers are immersed in collaborations with learners, practitioners, and stakeholders, to understand learning and contexts, and to co-design, implement, and evaluate designs through multiple cycles of optimization. In other words, there are many agendas to juggle.

Challenges to methodological fit

As argued at the start of this paper, with a plan for study design by orientation in Table 1, and illustrated through the examples synthesized in Table 2, methodological fit can support rigorous and relevant research. It can be challenging to attain, and is important to guard, as ideal research designs are rarely feasible in the dynamic settings of educational practice. Rather, grappling with methodological fit often represents a balancing act between research expertise (e.g. prior work, lacunas in the literature, methods that could address them), practitioner concerns (e.g. perceptions of relevance, cost/benefit of the data collection and collaboration) and practical constraints (e.g. obtrusiveness, timing, technological infrastructure). While methodological fit is often obtained eventually in published work (since it is a criterion attended to in most peer review processes), researchers frequently struggle with this fit in most studies, and especially in EDR studies in educational technology. Based on our experience in guiding and critiquing EDR projects, we warn researchers to avoid the following mistakes:

- *Asking beginner-level questions* In this case, the phenomenon being studied is treated as novel and therefore relies insufficiently on existing literature for conceptual framing. As a result, the study asks 'beginner' level questions, such as "Is online learning effective?". The answers may be new to the researcher and practitioners involved but are not new or research worthy to the broader scientific community. This challenge is particularly present in research for interventions.

- *Focusing on state-of-art rather than state-of-practice* Here, the potential of educational technology is taken as a starting point for intervention design, rather than the actual status and complexity of the research context. Technology as the starting point often results in proof-of-concept studies characterized by solutionism (solutions in search or problems) (McKenney & Reeves, 2020). This kind of work was noted in the call for this special issue, citing Reeves and Lin (2020) and their call to shift the focus from things (e.g. technologies) to the complex and emergent research-worthy problems to be solved in education (with technology). It is most prevalent in research on interventions.
- *Insufficient measures for causal inferences* While (quasi-)experimental methods may or may not be suitable for research for or on interventions, it is quite difficult to conduct research through interventions without them. And yet, we have encountered many researchers who indicated that it was either impossible or not relevant to gather pre/post data when evaluating the effects of an EDR intervention.
- *Absence of synthesis* This relates to results across orientations and sub-studies within a single project. It falls into the category of missed opportunity. It is present when theoretical and practical results from multiple studies within an EDR project fail to be compared, contrasted, or put together to create new insights. This kind of synthesis work can be published in journals, but because it reflects on previous findings, it often finds its home in books or the closing chapters of dissertations.

Conclusion

Our conceptual examination and practical analysis of methodological considerations in EDR via the three orientations and by using two doctoral studies serves to illustrate the types of issues that researchers must attend to as they navigate shifts in focus, questions, and methods over a trajectory. Given the complexity of EDR, and the broad understanding and skill required to draw upon and navigate multiple methods and approaches, it seems crucial to devote explicit attention to methodological fit, especially in the preparation and training of educational doctoral students. Supervisors and programs are well advised to consider the substantial and diverse demands that EDR can place on doctoral researchers who undertake this approach and ensure the quality and depth of supervision and mentoring is provided, along with program designs and communities that are supportive of an EDR approach (Friesen & Jacobsen, 2021), and by providing the necessary institutional supports, services, and resources. As part of doctoral education for educational design research, it is important to focus study designs from the start on methodological fit overall and precise questions and choice of methods within each phase, along with outlining knowledge engagement plans for communicating the results from multiple phases of EDR in appropriate peer-reviewed venues for both academic and professional audiences.

Change in the field of educational technology is unlikely to occur through richer qualitative or descriptive studies or by quantitative approaches to working with ever larger datasets. Barab (2022) argues it is our responsibility to pursue EDR that is methodologically rigorous, precise in its methods and explanations, and that generates theoretically useful claims the field considers convincing, informative, and useful for practice. We contribute a conceptual and practical elaboration of EDR study design and practice, and we have synthesized key insights from two methodologically rigorous EDR studies that employed precise research questions and mixed methods in multiple phases and cycles of optimization and theory generation, and that yielded theoretically and practically useful claims. We

explored the challenges and implications of EDR for the design of rigorous and relevant studies in authentic and complex contexts. We acknowledge that design as an epistemic mode would benefit from greater expansion and exploration, which was not undertaken in this paper. Conducting educational design research that is both robust and relevant is a challenge, "the simultaneous pursuit of practical innovation and theory building is ambitious" (McKenney & Reeves, 2020, p. 87); however, EDR offers an effective approach for both. We contend that recent research in diverse teacher education and health education contexts is useful for demonstrating the possibilities and opportunities of educational design research for generating theoretical insights and useful designs for practice (De Coninck, 2019; Meyers, 2017) in educational technology that moves both science and society forward (McKenney, 2018). The field needs more such EDR examples to inform and inspire others.

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Declarations

Conflict of interest The authors have no conflict of interest to declare.

Ethical approval Given this is a conceptual paper, it did not include primary research with human participants; thus, ethical approval was not required.

Consent to participate This work includes structured analysis of existing, published studies. As data were not collected from individuals, informed consent was not required.

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