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DESIGN RESEARCH – A PARADIGM UNDER DEVELOPMENT¹

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ZUSAMMENFASSUNG

Der Beitrag nimmt zunächst die unterschiedlichen Ansätze auf, die sich unter dem Begriff des ‚Design-Based Research‘ vereinen. Dabei wird ein Schwerpunkt auf die Herausarbeitung von konstitutiven Prinzipien gelegt, die als Bezugsrahmen und Kern eines Verständnisses von Design-Based Research dienen. Jedes dieser konstitutiven Prinzipien wird aufgenommen, auf seine zentralen Aussagen und Ansprüche hin erläutert sowie im Hinblick auf die in konkreten Forschungsprojekten zu beantwortenden Fragen spezifiziert. Die so vorgeschlagenen Regeln sollen einerseits den konstitutiven Forschungsphasen des Design-Based Research einen höheren Grad an Bestimmtheit und damit Verbindlichkeit verleihen, andererseits für die forschungspraktische Umsetzung von Projekten eine heuristische Orientierung bieten. Der Beitrag endet mit Fragestellungen, die in den nachfolgenden Artikeln aufgenommen und vertiefend erörtert werden.

ABSTRACT

The article covers a heterogeneous number of approaches and concepts which refer to the notion of ‘Design-Based research’. As a result, a framework with essential components and key principles is introduced to offer a common understanding of Design-Based Research. Each of these principles is explored by specifying the core requirements and discussing core questions and guidelines relevant to address while conducting research projects. The resulting rules are to provide both a clear guidance for the research practice and a starting point for methodological discussions among scientists. The article concludes by raising new questions which are to be addressed in the following articles.

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1 PREMISES

For the past 20 years, concepts such as “design-based research” (DESIGN-BASED RESEARCH COLLECTIVE, 2003), “design-experiments” (BROWN, 1992), development research (VAN DEN AKKER, 1999), “formative research” (NEWMAN, 1990), and “educational design research” (MCKENNEY & REEVES, 2012) have been discussed within a research orientation that can be summarized under the generic term “design research.” This research is characterized by the requirement that the development of innovative solutions for practical educational problems should dovetail with the acquisition of scientific knowledge. “The challenge for design-based research is in flexibly developing research trajectories that meet our dual goals of refining locally valuable innovations and developing more globally usable knowledge for the field” (DESIGN-BASED RESEARCH COLLECTIVE, 2003, 7). „Such research, based strongly on prior research and theory and carried out in educational settings, seeks to trace the evolution of learning in complex, messy classrooms and schools, test and build theories of teaching and learning, and produce instructional tools that survive the challenges of everyday practice“ (SHAVELSON et al., 2003, 25). Accordingly, design research is defined as follows: “the systematic study of designing, developing and evaluating educational interventions (such as programs, teaching-learning strategies and materials, products and systems) as solutions for complex problems in educational practice, which also aims at advancing our knowledge about the characteristics of these interventions and the processes of designing and developing them” (PLOMP, 2007, 13). Some years before the adoption of the US discussion in the early 1990s, SLOANE (1985; 1992) and EULER (1989; 1994) published research concepts that aimed to connect the three focal areas, namely theory formation, theory testing, and theory application.

While SLOANE employed the term “pilot project research,” EULER labeled his concept “science practice communication”. Although the majority of the projects was carried out in the teaching and learning research spheres, designed research can also be applied to problem areas in other educational research fields (e.g., curriculum development and teacher training). In addition, this research approach is by no means limited to the educational sciences (see VAN AKEN, 2005, for management theory and ÖSTERLE et al., 2010 for business informatics).

Design research emerged mainly in response to criticism of the lack of practical application of empirically and analytically orientated teaching and learning research’s findings. Numerous articles note that many scientific findings, for example, from traditional empirical research, are irrelevant for, inaccessible to, and/or incomprehensible for educational practice (see, e.g., EULER, 1996; 2007; 2009). Apart from its emphasis on practical relevance, design research regards its scientific function as not only describing and clarifying that which exists, but also the innovatively discovering and developing that which is possible. Both components – the increased practical relevance and the innovation function of science – constitute essential driving forces to legitimize and develop this paradigm.

2 THE DESIGN RESEARCH FRAME OF REFERENCE

First, the constituent attributes of this research framework are explained, followed by a detailed description and clarification of its paradigmatic guidelines in the next section.

Key question: This research's premise is not whether an existing intervention (synonyms: design, activity, problem solving) is effective, but the manner in which the desirable objective can best be attained in a given context through an intervention yet to be developed. The research examines "how to improve education and learning in authentic educational settings ... Further, that explicit goal becomes a day-to-day reference point for collecting and analyzing data, for making modifications to the intervention ..., and at the end of the investigation for determining the extent to which progress has been made" (REINKING & BRADLEY, 2008, 19). The thought and development direction therefore extends from the desired objective to the method. This research's premise and reference might, for instance, be the open question: How should an intervention be formulated within the context of a teaching concept (method) to advance specific (concretely recognizable) social competencies (objectives)?

Discovering, developing, and testing innovative solutions for unsolved practical problems. The design research objective is to contribute to the development of "innovative educational environments" (BROWN, 1992, 141) and simultaneously develop theories with practical relevance. Consequently, it commences with the search for and identification of significant problems in concrete practical contexts whose solutions demand an innovative approach. In terms of interventions, these solution approaches are not generally adopted but still need to be developed. The aim is thus to find innovative practical solutions for unsolved problems; i.e. the goal is not only to examine existing realities (actualities), but also to explore the possibilities (potentialities). "Design experiments differ from most educational research, because they do not study what exists; they study what could be" (SCHWARTZ et. al., 2005, 2). An attitude of having to "prove that" is not predominantly fundamental for this research, rather one of "exploring and testing what." Even though innovative teaching does not necessarily mean better education, the approach is associated with a demand to shape or change reality: "research can change reality rather than just study it" (SCHWARTZ et. al., 2005, 29). For example, iterative teaching concepts could be developed, tested, and formatively evaluated for a defined didactical framework (such as commercial training at school), which could offer a practical and innovative solution in terms of the targeted improvement of social competences. Simultaneously, these teaching concepts represent a viable intervention that could be applied to other contexts and developed into a theory with an increasingly larger scope.

Theory-based development: The development of innovative solutions is theory-based; i.e. it is underpinned by available scientific evidence, as well as experienced practitioners' available everyday theories. If, for example, the issue were the effects of new teaching concepts to be developed to improve social compe-

tences, practitioners' practical knowledge, as well as the relevant literature, would have to be incorporated into an intervention's design.

High practical relevance by means of iterative design cycles: From an economic research standpoint, more effort is initially spent on theory development to increase the practical relevance and/or the robustness of the intervention before a (if required, comprehensive) theory verification. "Therefore, we usually 'bet low' by conducting small studies, and then pursue the most promising results" (SCHWARTZ et. al., 2005, 20). Hence, one can resort to analogies from comparable practical areas. In the design of new products, software, or during organizational development, not every innovative variant is immediately subjected to a field test; instead, small design steps (prototypes) drive the innovation's gradual development. With respect to research, interventions with a high practical relevance should be based on extensive research. Everything that is relevant should also be measured before the accuracy of the data is considered. In this way, individual learning groups could explore the effectiveness of the developed educational approaches, allowing significant weaknesses to be recognized and corrected, and thus incrementally increasing the concepts' maturity and robustness.

Cooperation between science and practice: Experienced practitioners are included in the different phases of the research and developmental process, thereby opening up other approaches to research fields of practice as opposed to "distant research." The expectations are that solutions' quality will increase and the transfer of collectively developed (and thus practicable) theories will be improved in practice (see also EULER, 2000, 573ff.). For example, experienced practitioners normally have an extensive know-how and a strong intuition regarding where the critical events in a developed teaching concept's application are to be found. Including experienced practitioners can make this frequently implicit knowledge useful for the development phase and can shorten the route to a high-quality intervention.

Area-specific theories as targeted results: On the one hand, design research strives to achieve concepts or theories that will be useful for current practices. In this context, MESSICK (1992) calls this "consequential validity"; i.e. the results provide a demonstrable added value to the design of teaching-learning processes. On the other hand, theories are pursued that transcend a learning situation's application area. Design research does not only pursue an explanation of interventions' effects in a singular learning environment, but attempts to formulate "prototheories" of learning and/or area-specific theories that fit into a broader context (see also Cobb et al., 2003, 10f.). The theories primarily incorporate design principles tested for a designated application context ("contextually-sensitive design principles and theories") (see VAN DEN AKKER, 1999; REEVES, 2006).

For example, a project's result could be practically proven teaching concepts, which, in addition to a concrete product, offer the practitioner design principles whose basis could generate suitable concepts for similar situations. While these principles provide fundamental orientation, they do not exonerate practitioners from the task and responsibility to transfer these concepts to new application conditions. Analogously, the scientific findings are not formulated as technological

instructions, but as design principles. In this context, ULRICH & PROBST call them “order patterns,” which thus mean that the conditions of a system cannot be predicted exactly, but can be determined within limits and uncertainties. This is aptly demonstrated with the example of a tree: While it is impossible to determine at what exact hour its leaves, blossoms, buds, and fruit will appear, it is possible to predict approximately when it will bloom, when its fruit will ripen, and its leaves fall (ULRICH & PROBST, 1991, 66ff.).

Design principles may be deemed modest compared to general technological propositions’ demands regarding the guidance of objective-oriented actions. This leads to the fundamental question: What type of proposition can realistically be expected in a field as highly complex as learning and teaching? Design research proceeds from the assumption that research cannot provide practical actions with certitude, but “merely” a more or less empirically and/or theoretically well-founded orientation. For example, in education, team work success requires learners to understand the formulation of a problem they view as challenging. How these two principles are translated into a concrete situational context depends on the teacher’s adaptation. It follows that research findings do not have an immediate effect on actions in the form of fully prepared proposals, but indirectly “through the minds” of practitioners. The significant insights necessary for practical actions are therefore not determined by “scientific experts,” but by the practitioner’s assessment of the usefulness of existing scientific and other theories. Practitioners and/or, in this case, teachers can utilize design principles because they indicate trends and offer indications of a method’s successful application under certain conditions; at the same time, they are obliged to interpret these principles within the concrete didactic situation that they have to create (see EULER & HAHN, 2007, 318).

3 OVERVIEW: PROCESS MODEL OF DESIGN RESEARCH

The research and development process of a paradigm is mostly represented by the demarcation of characteristic phases or steps. Although the numerous process models by various authors (see MCKENNEY & REEVES, 2012, 73; REINKING & BRADLEY, 2008, 67ff.) differ in their number of phases and notional descriptions, their basic structures display a high degree of similarity. The following text outlines the basic structure of a process model (see EULER, 2011, 533), thereafter including the individual phases and clarifying the paradigmatic guidelines in the next section.

The research and development process is realized in iterate cycles of design, testing, analysis, and redesign. An incremental optimization of the design is effected within these cycles, and the development processes and principles are simultaneously documented. A supporting element in this respect is the formulation of hypotheses that are examined in the course of the development process. If proven wrong, they are not rejected, but lead to the formulation of modified hypotheses. This approach is closely related to the idea of the progressive search for

knowledge in the context of research programs, as advocated by LAKATOS (1974). “One of the distinctive characteristics of the design experiment methodology is that the research team deepens its understanding of the phenomenon under investigation while the experiment is in progress” (COBB et al., 2003, 12). The research and development cycles can start at different levels. For example, in the context of microcycles, the intervention within a classroom was developed iteratively, while its application range within the context of macrocycles was extended to other classes or schools. (see GRAVEMEIJER & COBB, 2006).

The interventions should only be summatively evaluated after an advanced refinement; i.e. the development potentials of the interventions should be exhausted before an approach is rejected as lacking usefulness (see LEWIS, PERRY & MURATA, 2006, 8). The following diagram outlines the basic sequence of a design research and developmental process, and identifies the targeted results for the individual process phases:

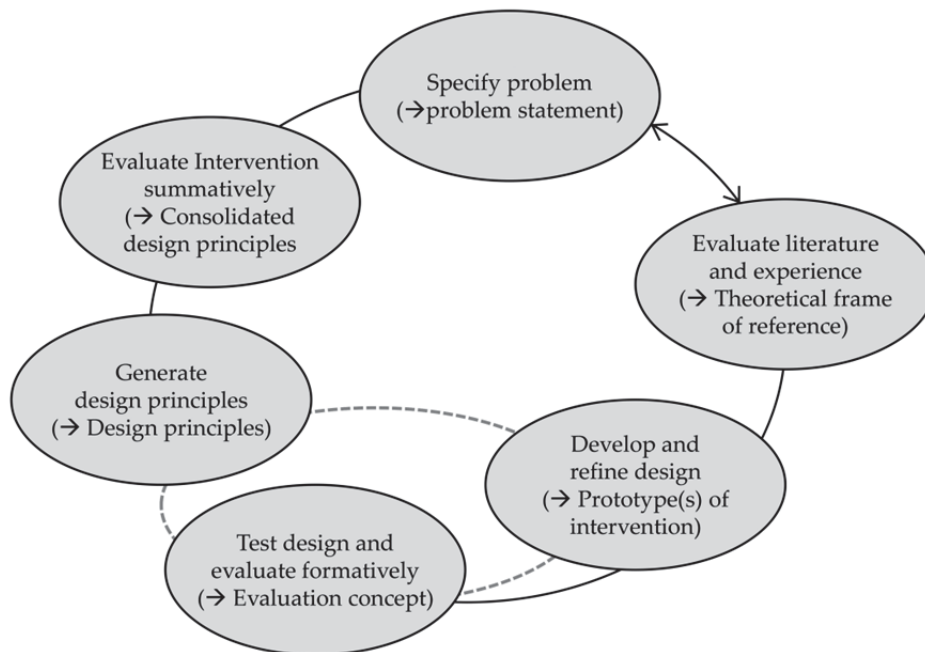


Figure 1: Research and development cycles in the design research context

Defining the relationship between science and practice in terms of mutual interaction is a key element of the approach. In the course of forming, testing, and applying of scientific theory development, stakeholders from academia and practice can pursue their different goals and interests in cooperation with each other (see EULER, 1994, 239). Their interests differ in that:

- science is primarily interested in collecting and examining viable theories, whereas creating a field of practice is secondary;

- practice is primarily interested in developing solutions for problems considered relevant and urgent, and regards developing and formulating suitable everyday theories as secondary.

Integrating the forming, testing, and applying of theories leads to a win-win situation for both parties. Science can select its research topics from problems in practice, while developing solutions for practice is enhanced by resorting to scientific theories. In ideal circumstances, both sides would profit, thereby enhancing the quality of the practical problem solving and the scientific theory. Against the background of their differing interests, communication between science and practice can only succeed if practice is open to scientific theories' different perspectives and, vice versa, if science can accept practice's experience and everyday theories, merge these with their own, and communicate them. In this way scientific and practical action combine in a process of mutual learning in which, "on one hand, structurally contrasting scientific theories (the researcher) have to expand, relativize and complete the basic knowledge (the object of research), while, on the other hand, the complexity and concretization of everyday theory should correct and complete scientific knowledge" (HEINZE, 1987, 32; own translation). This approach rejects the assumption that the experts (in science and/or practice) can only exchange knowledge between themselves. Science is, therefore, not only an instrument of criticism, description or explanation of practice, but also one of design in terms of the discovery, development and testing of concrete solutions in and with practice. Since science does not suffer the time and decision-making pressure that practice experiences, it has a different perspective on the construction of actuality and potentiality, and/or the development of alternative interpretation and action possibilities.

4 PARADIGM-CONSTITUENT GUIDELINES FOR THE DESIGN OF THE RESEARCH AND DEVELOPMENTAL PROCESS

4.1 On the function of paradigmatic guidelines

Scientific inquiry follows specific rules. A community of scientists determines these rules and the context in which they should be applicable. Individually, the rules relate to the various facets of knowledge acquisition; collectively, they are frequently summarized as paradigms. "A paradigm constitutes that which members of a scientific community [...] have in common. [...] Such communities are characterized by comparatively strong communication within the group and comparatively unanimous judgments regarding specialist issues" (KUHN, 1978, 390f. - own translation). SLOANE describes a paradigm as a normative structure "arising from the researcher's social relations and all of his pervasive actions. This structure determines the tasks, problems, etc. that a researcher wants to solve and, primarily, the methods that he would use. Paradigms are thus like transparencies that prestructure research access, research methods, and the interpretation of the research results" (SLOANE, 1992, 141 - own translation). Since the agreement of

paradigms is regarded as a result of social construction, different paradigms can juxtapose or contradict one another.

There is as yet no detailed fixed set of rules for design research, as there is for established paradigms. This is hardly surprising given the relatively recent origin of design research. An endeavor is made below to create the premise to develop a paradigm-constitutive normative structure for the scientific community of design researchers by providing the foundation and the justification of the guidelines.

It is important to clarify what exactly is meant by rules and guidelines and precisely how these govern scientific actions. The differentiation between them already suggests differing degrees of bindingness. When examining existing paradigms (e.g., hermeneutics and critical rationalism), we find that while some constitutive principles are indeed identifiable, a project's concrete research practice extends beyond adherence to these principles through a multitude of specific approaches that individual researchers employ. This observation coincides with a universal understanding of the philosophy of science, which rejects the notion that scientific action can be understood as following a fixed rule in the sense of a mechanized routine (see LAKATOS, 1974, 272). "Rather, the rules relevant for the creation of scientific theory have a heuristic potential for scientific researchers, which lends their research an orientating guideline" (EULER, 1994, 242 – own translation). ALBERT, one of the main proponents of critical rationalism, argues in this spirit when he emphasizes that "each rule only delimits the scope for a behavior, within which one always retains design options, even while adhering to the rule. The relevant scopes can differ in magnitude and the achievable canalization that the fixed rules allow for an action can therefore be wider or narrower so that even with a rule-governed action there is still room for imagination" (ALBERT, 1980, 29 – own translation). "Even (knowledge acquisition) does not presuppose a developed technique or even a formulated technology – or methodology – within which all relevant principles are utilized. [...] The methodological practice of the sciences is as much in need and capable of development as the other spheres of human life" (ALBERT, 1987, 73; see also 93, 119, 161 – own translation).

These rules should not be viewed as a rigidly binding straitjacket, but as a flexible and manageable instrument for the scientist. The increased openness increases the degree of uncertainty and opacity for the evaluator of developed scientific theories. The decision to identify paradigm-constituent rules lies in this area of tension - flexibility and openness of rule implementation in the interest of theory building that is appropriate to the problem, clarity, and cohesion in the interest of a transparent traceability of results. FEYERABEND holds an extreme viewpoint in this discussion with his argument that one cannot introduce and discuss principles independently from concrete research problems, because "these principles differ from case to case" (FEYERABEND, 1986, 11 – own translation). He not only determines that scientific rules are often violated *de facto*, but asserts, with reference to the history of science, that one has to violate them in order to make headway in sciences (see FEYERABEND, 1981, 28, as well as 257ff.). PUTNAM (cited in: RORTY, 1988, 20) views scientific actions not as the application of rules in individual cases, but as the "ceaseless re-weaving of a network of beliefs." In keeping

with this viewpoint, RORTY describes research not as something which is converging, but as something flourishing, where “discovery” and not “making” is emphasized (RORTY, 1988, 23).

In the context of these different perspectives, the position that paradigms, such as design research, should be constituted for scientific actions by *rules in terms of heuristic guidelines* is advocated below. Consequently, paradigmatic rules represent exploratory open-ended guidelines that can be modified, enhanced, and discarded. They should, more or less, be treated as *general* principles that can be applied in accordance with the research problem. Only *specific* problems will have concrete rules. On this basis, paradigms represent a scientific action model that includes and describes selected aspects it deems meaningful. According to FEYERABEND, in concrete research projects, the approach can be investigated as a material in the context of a “historically illustrated rule of thumb” that “strengthens the ingenuity of the learner, enabling him to invent rules suitable for new cases” (FEYERABEND, 1986, 189 – own translation).

Even though there is a gap between the paradigmatic rules, in the sense of a heuristical guideline and concrete scientific actions, the transparent identification of the employed principles presupposes the traceability of scientific action. The identification of the respective rules primarily creates the condition for a possible rational discussion - and thus permits substantiated contradictions and/or criticism of a paradigm’s practical application and/or the concrete realization of a research project.

The framework of rules proposed below refers to the design research process model introduced in section three. On the one hand, the proposed guidelines result from an examination of the current literature, which seldom has detailed, direct references to methodical rules and/or principles, but frequently indicates implicit orientation towards the research process’s core activities. On the other hand, own, as well as outside, research activities are both reflected in the guiding questions considered here. Below, the six phases of the process model are presented as action fields and explained with regard to the following aspects:

- The core requirement of the action field in question
- The core questions for which the researcher should find an answer, as well as applicable guideline for scientific action
- The result.

4.2 Specify problem

Core requirement

If we accept the precise specification of a problem as the premise of design research, then there is, at first, no fundamental difference between this rough description and other paradigms. However, an inspection of the type of problem indicates specific features: An investigation is needed of how a desirable objective can be achieved in a defined context and through an intervention that still needs to be developed. For example: How can group processes be shaped so that learners

in a classroom setting develop team competencies? How can a socially responsible set of actions be developed in management training? How can vulnerable adolescents attain more resilience during the transition to apprenticeship and employment?

A precise specification of the desired objective, of the framework to develop appropriate avenues, and of the elaboration of the innovation claim is therefore fundamental for design research. “The identification of problems in design research thus involves finding a problem that is worthy of investigation and capable of being solved through the research process” (MCKENNEY & REEVES, 2012, 185).

Problem specification should be effected from two perspectives. From a scientific perspective, the central contribution comprises identifying the relevant theories and including them in the research process. The practical perspective entails, on the one hand, an understanding of the practical framework conditions for the development of innovative problem solutions and, on the other hand, the activation of the available experiential knowledge. The targeted activation of practical knowledge can thus strengthen the practice’s commitment to or ownership of the design project.

In the process of problem specification, a possible area of conflict is an excessive emphasis on the restrictions of or orientation to well-functioning routines that obscure the view of innovative approaches. In this context, MCKENNEY & REEVES (2012, 85FF.) differentiate between two roles, namely that of detective and inventor that should - in line with the analysis and exploration - be both performed and balanced.

Core questions and guidelines

- 1st What objectives should be achieved and/or which problems should be solved?
(State objectives transparently!)
- 2nd What conditions exist in practice that can support or constrain the achievement objectives?
(Outline framework conditions!)
- 3rd Are essential insights to attain objectives that are not yet available?
(Justify scientific relevance and degree of innovation!)
- 4th Are the objectives for the relevant practice meaningful and/or is their achievement pursued?
(Justify practical relevance!)
- 5th Are partners (especially critical ones) from practice willing to contribute their experience to develop a problem solution with science?
(Acquire practical expertise!)
- 6th Have the objectives and expectations of the partners in a scientific-practice cooperation been clarified?
(Clarify framework for cooperation!)
- 7th What potential does the desired solution have for an extended application?
(Justify the transfer potential and possible degree of generalization!)

- 8th Is the desired solution feasible within given time limits, personnel, and material resources?
(Estimate feasibility!)

Result

A problem statement identifying the (key) objectives related to (as yet provisional) research and design issues. In addition, a justification of the research issue's practical and scientific relevance.

4.3 Basic theoretical concepts: Evaluate literature and experience

Core requirement

Specifying and developing innovative problem solutions are theory driven, i.e. they are closely linked to the analysis of the literature and practical experience. MCKENNEY & REEVES (2012, 91ff.) distinguish between three central activities in this area: setting up the initial orientation, field-based investigation, and a literature review. Setting up the initial orientation and implementing the field-based investigation follow open core questions such as: What does problem definition comprise? What is meaningful with regard to the practice context? Which stakeholders should be considered in practice and what is important for each of them? Which qualifications (knowledge, views, accomplishments) do these stakeholders contribute? What added value could an innovation achieve compared to current practice? An analysis of the literature can put singular observations in a wider context, stimulate initial ideas for the development of solutions, and demonstrate connections to relevant investigations and research results from related fields.

Core questions and guidelines

- 1st Which scientific disciplines or discourses have theories that offer substantial explanations for dealing with research and design issues? To what extent is it possible to tap into the range of relevant research findings?
(State choice of scientific theory approaches!)
- 2nd Which stakeholders and experts have experiential knowledge that offers substantial explanations for dealing with research and design issues? To what extent is it possible to activate tacit knowledge from the field?
(State choice of practical knowledge!)
- 3rd What degree of corroboration do the available explanations possess? Do these present untested suppositions, or have they already been tested and evaluated in appropriate practice fields?
(State the degree of corroboration of the theoretical basis!)
- 4th What degree of relevance do the identified explanations / theories have for attaining the objectives? Are they building blocks for a solution, or of no, or merely marginal, importance?
(Evaluate the importance of the employed theoretical basis!)

- 5th How can available scientific and everyday theories and practical knowledge be connected?
(Integrate and demarcate different theory approaches!)
- 6th Which issues remain open, unclear, and uncertain in respect of the development of a solution in order to attain the desired objective? Where are the unresolved aspects in the development and testing of possible solutions (or interventions)?
(Focus on open research and design issues!)

Result

Theoretical frame of reference with a (further specified) problem definition, the design requirements (“specification sheet”), and preliminary descriptions of possible measures (design hypotheses) for attaining the desired objectives.

4.4 Develop and refine design

Core requirement

Despite being firmly rooted in theoretical concepts, first designs are seldom an optimal intervention to achieve an objective. Consequently, – and contrary to practice regarding the development of empirical intervention studies – design research emphasizes developing a targeted and robust intervention before testing it in a wider context. Nonetheless, in this phase, design research too experiences the conflict between “a good and a better solution”; i.e. an assessment has to made whether further improvements merely add marginal value and when the basically endless search for a solution should end. Once again, the attitudes of the inventor (who wants to pursue every idea) and the detective (who pragmatically ponders them) should be balanced. The particular quality of this phase is the ability to harvest high-hanging fruit during the development without becoming fixated by interventions that can only be realized in exceptional circumstances. Design development can be guided by the questions below (see. MCKENNEY & REEVES, 2012, 175ff.):

- Is the intervention conclusive, understandable, and appropriately targeted?
- Is the intervention applicable in principle?
- What is the intervention’s added value in comparison to previous practice implementations.
- What makes the intervention attractive for potential users from practice?
- What user competencies (knowledge, accomplishments, attitudes) are presumed for the implementation of the intervention?
- Where do the critical events and/or difficulties in the implementation of the intervention lie and how can they be overcome?
- To what extent does the intervention allow for a flexible adaptation under varying application conditions?

Cooperation between science and practice also promises a performance advantage in this action field. Experienced practitioners usually have an extensive

knowledge and intuition of where the critical events lie when implementing a design in practice. Their participation can make this – frequently implicit – knowledge useful for development and shorten the path to a high-quality intervention. The responsive inclusion of experienced practitioners in the development of interventions not only increases acceptance of innovation in practice, but also the probability of a transfer of the results beyond the relevant testing practice framework.

However, one should not forget that science and practice ‘s interests can diverge in an actual project. This can manifest itself via different attitudes during the design development process – prototypically contrasted by the difference between science’s critically evaluative attitude and practice’s design-oriented and decision-oriented position (see EULER, 1994, 228). A win-win collaboration of science and practice can, therefore, not be assumed, but has to be developed throughout the project and made tangible for its participants (see EULER, 1994, 273ff.).

If the interventions are incrementally refined, a key task is the recording of the genesis of the knowledge acquisition, particularly with regard to its traceability. The literature proposes various approaches, such as the “conjecture map” (SANDOVAL, 2004) and “design narratives,” which are structured from scientists and practitioners’ perspectives (see KNOWLTON, 2007). A documentation structure for these, in part, elaborate approaches could look as follows:

	Version 1	Version 2	...	Version n
Influencing factors / framework conditions			...	
Design characteristics			...	
Evaluation results			...	

Core questions and guidelines

- 1st Do the designs seem suitable to achieve the desired objectives in principle?
(Justify the suitability of the objective!)
- 2nd Are performance advantages exploited when science and practice cooperate in design development? (Activate performance advantages and unshared knowledge in the cooperation between science and practice.)
- 3rd Has a foundation of trust been established in the process of cooperation and has the interchange between science and practice intensified, in order to increase the potential for more in-depth knowledge and design possibilities?
(Develop a foundation of trust and interchange between science and practice!)
- 4th Can the developed designs be realized in practice and can their effectiveness be verified? (Justify the feasibility and verifiability of the design!)

- 5th Are the designs formulated in such a way that practitioners will be able to understand and apply them? (Ensure a comprehensible design!)
- 6th Are the design structures and modifications clearly documented to differentiate them from earlier versions? (Document the design's structure and developmental changes!)
- 7th Are the designs specified in terms of important characteristics and factors that should be more closely observed and tested? (State possible key aspects for the verification of the designs!)

Result

Prototype(s) for potential interventions and/or measures to achieve the desired objectives (within the theoretical reference framework).

4.5 Test design and evaluate formatively

Core requirement

Design research connects development with testing and the (initially formative) evaluation of innovative problem solutions. On the one hand, testing and evaluation aim at exploring how applicable the designs are in authentic practice contexts, on the other hand, further improvements should be identified during the implementation. "Some of the most powerful findings will be serendipitous, and the data to support them will be marshaled post hoc." (SCHOENFELD, 2006, 202) This corresponds to Dewey's viewpoint and his concept of "collateral learning" (cited in: REINKING & BRADLEY, 2008, 51).

The evaluation should progress methodically and systematically, while a corresponding evaluation concept takes the following aspects into account (see MCKENNEY & REEVES, 2012, 133):

- definition of the evaluation focus
- formulation of core questions
- selection of evaluation strategies
- definition of specific evaluation methods and instruments
- acquisition and assessment of data
- documentation of results

When *defining the focus* it is possible - with respect to the degree of maturity attained by the intervention - to distinguish between Alpha, Beta, and Gamma tests. While the main focus of the Alpha test is on the intervention's internal consistency and practical feasibility, the Beta test concentrates more on the optimization of potentialities and approaches to strengthen sustainability. The Gamma test measures the efficiency and effects of the intervention intensively with appropriate instruments, although the relatively small test samples do not permit generalized results. In this way, the focus of the formative evaluation shifts from an understanding and description of what does (not) function in the design to an estimation and assessment of what design components do (not) contribute to the achievement of objectives. The respective key aspects are determined by the cor-

responding *core questions*. Based on the Alpha test, these could be: In which treatment was the design tested? On which of the design components are focused during the evaluation? What changes are noticeable during testing? Under which framework conditions was testing carried out?

The evaluation can be oriented towards four specific strategies. (1) Within the framework of a developer screening, the internal structure and consistency of the intervention are most important. The development of the intervention is discussed by means of focus groups, checklists, and document analyses and the suitability of the objectives are pondered. (2) To obtain expert appraisal, external experts are approached for a validation, critical appraisal, and suggestions to further develop the intervention. Consequently, further perspectives can be included in the development process. (3) The intervention is tested live in a pilot test with a small sample during which the full complexity of a real situation is not yet generally effected. This occurs in the framework (4) of a tryout. MCKENNEY & REEVES (2012, 143) associate evaluation focus and evaluation strategy in the following figure²:

		Developer screening	Expert appraisal	Pilot	Tryout
Alpha	Feasibility				
	Soundness				
Beta	Local viability				
	Institutionalization				
Gamma	Effectiveness				
	Impact				

Within the framework of evaluation, design research employs a diversity of data acquisition and assessment methods that is also applied in other research approaches. “[It] relies on techniques used in other research paradigms, like thick descriptive datasets, systematic analysis of data with carefully defined measures, and consensus building within the field around interpretations of data” (DESIGN-BASED RESEARCH COLLECTIVE, 2003, 7). The acquisition and analysis of qualitative data is of crucial importance because the development of innovative problem solutions also necessitates the identification of the contextual factors that are relevant for the intervention’s effectiveness. The following overview combines the evaluation methods and strategies (see MCKENNEY & REEVES, 2012, 147):

2 The darkness of the filled-in cells indicates their degree of importance.

Methods	Developer screening	Expert appraisal	Pilot	Tryout
Interviews				
Focus groups				
Observations				
Questionnaires / checklists				
(Pre/post) tests				
Logs / journals				
Document analysis				

The documentation of the results constitutes a specific methodological aspect. Here, the challenge lies in reducing the rich material to essential core statements and putting them into a theoretical context, while at the same time preserving the wealth of detail. BELL et al. call this: “design narratives” that “tell the story of the events leading up to, during, and following the investigation. Design narratives help make sense of design studies by including compelling comparisons as well as more informal research” (BELL et al., 2004, 79). They include, among others, the framework conditions, central activities, and observable effects of the intervention. Moreover, they include the participants’ assessments regarding the attainment of the pursued objectives, and, especially, cues to the intervention characteristics that are being critically assessed.

Core questions and guidelines

- 1st Does the design test display the utmost consideration for the variation in diversity in practice (e.g., with regard to the participants’ characteristics and the relevant framework conditions)? (Capture variations in practice!)
- 2nd What key aspects and questions should predominate in which design phase during the formative evaluation? (State evaluation questions!)
- 3rd Are an increase in knowledge and the generation of design alternatives worth the effort to collect data, assess it, and document the results in each design phase? (Ensure assessment economics!)
- 4th Do the survey and the evaluation of testing experiences include the widest possible variation in scientific perspectives? (Facilitate multiple perspectives for the evaluation team!)
- 5th Is the evaluation concept suitable to capture, on the one hand, possible effects from selected factors while remaining open to unexpected events and/or previously unnoticed factors, on the other hand? (Balance focus and openness in the evaluation!)
- 6th Does the evaluation succeed in ensuring thick descriptions from different perspectives (“researcher / participant narratives”), while identifying key points for further development during the processing of the findings? (Focus data evaluation on key points.)

Result

Evaluation concept with explanation of data collection, assessment, and method to discuss the implications of the findings.

4.6 Generate design principles

Core requirement

An interesting point when discussing the approach is the extent to which the demand to acquire generalizable results – that, is the quality criteria of empirical and analytical research (objectivity, validity reliability) – is applicable to design research. On the basis of these quality criteria, questions such as the following are formulated: “To what extent can rival narrative accounts of the same action be ruled out? To what extent would another narrator replicate the account? To what extent does the narrative generalize to other times and places? ... To what extent would the tool developed in one intensively engineered setting generalize to another setting?” (SHAVELSON et al., 2003, 27). While the theory-building character of design research remains largely undisputed, its potential to rigorously test theories remains doubtful. The arguments posited are reminiscent of the debate on the “science” of qualitative research design. Consequently, new research approaches are measured according to criteria that were developed and are valid for other approaches. In contrast, exponents of design research point out that “these qualities are managed in noticeably different ways than in controlled experimentation” (BARAB & KIRSHNER, cited in: DESIGN-BASED RESEARCH COLLECTIVE, 2003, 7). Given this background, what does the demand that scientific results should be generalizable mean? Does this demand differ in the context of the design research framework from empirical and analytical research?

Design research views generalizability as an essential characteristic of the results to be achieved. “We must operate always under the constraint that an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and for average students and teachers, supported by realistic technological and personal support” (BROWN, 1992, 143). Generalization is pursued in the form of design principles; “they recommend how to address a specific class of issues in a range of settings” (MCKENNEY & REEVES, 2012, 19). “Design-based research is a research methodology aimed to improve educational practices through systematic, flexible, and iterative review, analysis, design, development, and implementation, based upon collaboration among researchers and practitioners in real-world settings, and leading to design principles or theories” (WANG & HANNAFIN, 2004, 2). Design research results therefore do not represent “statements of law”; rather, “they provide guidance and direction, but do not give ‘certainties’” (PLOMP, 2007, 22).

Design principles can be expressed in the following form: “If you want to design intervention X [for the purpose/function Y in context Z], then you are best

advised to give that intervention the characteristics A, B, and C [substantive emphasis], and to do that via procedures K, L, and M [procedural emphasis], because of arguments P, Q, and R“ (VAN DEN AKKER, 1999, 9). The principles could therefore apply to a subject area (what should an intervention look like?), as well as the process (how should the intervention be developed?) (see VAN DEN AKKER, 1999, 5).

The following examples illustrate how design principles can be applied:

- A learning design (intervention) to improve team competencies (the objective to be defined more precisely, if necessary) should, among others, take the following components into account: (1) presentation of a problem whose solution requires cooperation between learners; (2) the learners' clarification of and agreement on the objectives; (3) the group of learners activating unshared knowledge; (4) teachers' reflection-stimulating feedback on the group's work results; (5) avoidance of teachers' invasive interventions in group processes; (6) reflection on the factual and social dimensions of the experienced group processes.

The components can be initiated by the following activities and can improve team competencies for the following reasons: (... enumeration ...)

During the development and adaptation of the intervention for its respective application conditions, the following aspects should be considered: (... enumeration ...)

- A measure (intervention) to improve the moral obligation of leaders (the objective) should cover the following components: (1) a problem for reflection on moral dilemmas; (2) linking the problem to learners' personal responsibilities and fields of experience; (3) raising awareness of implicit value systems that become apparent in the reflection processes; (4) avoiding teachers' value-imposing interventions; (5) an active call on learners to articulate and justify their value systems when there are conflicts of value. The components can be initiated by the following activities and have the potential to achieve their objectives for the following reasons: (... enumeration ...). During the development and adaptation of the intervention for its respective application conditions, the following aspects should be considered: (... enumeration ...)

Design principles can be formulated on different abstraction levels. EDELSON (2008) combines a collection of different design principles of one field of action into a 'design framework.'

From this characterization it is clear that design research follows a different understanding of generalization than quantitative empirical research approaches. In these, generalization is understood in terms of a statistical relationship between the sample and total population, whereas, in design research, it is inductively based on the comparative analysis of individual cases and the explanation of similarities and differences (see KELLE & KLUGE, 2008; EULER, 1994, 269ff.). Both forms of generalization have potentials and limits. Design research's strength lies in its reference to unlimited complex practice, its limitation lies in a reduced number of test cases that is justified by restricted research resources. Quantitative so-

cial research is based on a large sample size, but limits its focus to a more or less narrow practice segment. On the basis of the examples outlined above, it can be demonstrated that the complexity of social structures and processes limits the validity of the examined theories, because theories do not explain many of the variables that make didactical actions so incalculable and difficult.

Core questions and guidelines

- 1st What are the case-specific unique facts and features and what are the transferable, generalizable ones when the different findings are compared? (Analyze case-related tests and commonalities!)
- 2nd What validity claims and orientation potentials do the developed design principles need to have to attain the pursued objectives? (Estimate the knowledge and design potentials of the design principles!)
- 3rd What methods (e.g., comparative case analyses, reflection, reduction) are employed when generating design principles? (Identify a methodical approach for the development of design principles!)
- 4th To what extent do design principles represent new findings and how do they transcend existing knowledge? (Identify the research's degree of innovation!)

Result

Design principles for a defined area of application.

4.7 Evaluate intervention summatively if applicable

Core requirement

Once the intervention has gained sufficient stability and robustness, it can be subjected to a summative evaluation. Summative evaluation studies make use of a larger population sample to test whether the developed measure has the desired effect. At the same time, a check should be carried out to ensure that the observed effects are, in fact, attributable to the measure. Consequently, in an actual form (treatment), the developed measure is defined as an independent variable and the pursued objective as a dependent variable. The distinction between the variable and its expression is essential as an actual examination would not, for instance, examine team work's effect on the development of team competencies, but the effect of a specific and distinct group work on the development of the (to be refined) team competencies. Strictly speaking, the effects (possibly) observed would generally refer to the actual characteristics of the studied team work, and not team work in general. It should be noted, however, that in contrast to a formative evaluation, which emphasizes the intervention's exploratory optimization, causal relationships are reviewed in a summative evaluation. Depending on the extent and degree of differentiation, it is possible to differentiate between small-scale and large-scale summative research. For example, small-scale summative research evaluates "what can be achieved with typical teachers under realistic circumstanc-

es (...). In four to ten classrooms, pre- and post-test, randomized, experimental designs using measures of learning are used“ (CLEMENTS, 2008, 416). In contrast, large -scale summative research expands the scope - for example, in the context of curriculum development - to include the “effects in contexts where implementation is usually expected to vary widely (...) and the critical variables, including the contextual variables -- settings, such as urban/suburban/rural; type of program; class size; teachers' characteristics; students'/families' characteristics -- and the implementation variables -- engagement in professional development opportunities; fidelity of implementation; leadership and support; peer relations; and incentives used (...)” (CLEMENTS, 2008, 417f.) In addition, the underlying impact hypotheses can differ in complexity and range - from simple to complex multivariate hypotheses.

The hypotheses can be embedded in different research schemes (see Bortz & Döring, 2006, 115ff.). In this context, a relevant design would be an intervention study in the context of a “before-and-after measurement in a comparison of experimental and control groups” (see Schnell, Hill & Esser, 2005, 213f. – own translation). The developed intervention concept is therefore tested in experimental groups, while a meaningful alternative concept based on “routine practice” (or a placebo) is applied in the control groups. In this case, a longitudinal study has an advantage over a cross-sectional study as conclusions can be drawn regarding the causal relationships and the changes measured.

The methodical implementation of summative evaluation studies can access an elaborate repertoire of rules and standards (see, e.g., Schnell, Hill & Esser, 2005; Bortz & Döring, 2006). When assessing the obtained results' validity, it is of significance that summative evaluation studies are susceptible to “disruptive factors.” For example, factors outside the intervention, and which were not checked, could have caused the effects. Other possible “disruptive factors” include the subjects' learning and reactance effects, as well as biased choices or missing values in the random samples (see Schnell, Hill & Esser, 2005, 217ff.). The quality of a research design relies, among others, on the extent to which the influence of these disruptive factors is limited. Nonetheless, there is consensus that this cannot be perfectly done. Against this background we can understand Cronbach's (1982) conclusion that, after evaluation, “the art of the possible” should frequently be submitted to pragmatic criteria.

Given the comments on the validity and generalization range of design principles resulting from design research, and the limitations of summative evaluation, the question should be: What can be expected from its results? It should also be emphasized that the identified cause-effect relationships in social processes, like those in education and learning, are not deterministic but, at best, of a probabilistic nature. One problem is that concrete investigations do not review straightforward interventions, but rather the effects of treatments in complex contexts. Since the treatments are, strictly speaking, unique and only approximately replicable, research findings are frequently contradictory because they relate to different treatments. These tendencies are increased by “disruptive factors” in the corresponding research design that are unavoidable and cannot be completely eliminat-

ed. This is illustrated by EULER's (2012) analysis, which evaluates different authors' research studies on the relationship between action-oriented learning and competence development. Depending on the study, there is either support for or against the use of action-oriented teaching arrangements to develop the researched competence constructs. Ultimately, and despite numerous studies, it is impossible to prove the links between methodological fundamentals and the development of competences, or to refute them.

Despite the inherent limitations of the summative evaluation results, they can, in conjunction with findings from formative evaluation cycles, enrich the assessment of developed interventions. The results should be presented in a synopsis and – in keeping with design research's premise – be processed with a view to offering practitioner potential options. Given the outlined limitations of summative evaluation, the results will at best deliver refined design principles or action heuristics that practitioners can adopt and transfer to their specific practice situations.

Core questions and guidelines

- To what extent does a summative evaluation of the developed measure provide additional insights that will justify the research and economic resources when compared to that of a formative evaluation? (Justify the benefits of summative evaluation!)
- Does the educational practice in question present a field of research that ensures compliance with central standards (such as experimental / control group design; choice and size of sample; acceptable response rates for data collection) for the implementation of a summative evaluation? (Ensure implementation of appropriate research standards!)
- To what extent can “disruptive factors” be anticipated and limited by taking appropriate steps in the research design? (Identify disruptive and risk factors that are essential for the interpretation of the results!)
- How can results from the summative evaluation be linked to design principles to strengthen the intervention's overall validity? (Adapt the results of the formative and summative evaluation phases with regard to their potential consequences in practice!)

Result

(Refined) *design principles* and/or *action heuristics* for practical actions in a demarcated action field.

4.8 Communication between science and practice

The three research models by SLOANE (2006), each with their specific relationships between science and practice, seem to be instructive (see also STOKES, 1997, 73):

- Distanced research: The practice is the object of research and, in this context, both empirical-analytical approaches and those from the humanities come into play. In the first instance, practitioners are interviewed and observed; in the second, they are the subject of distanced reflection; in certain circumstances, they may also be included to validate the findings.
- Intervening research: This type follows the action research approach. The practice is subject to change and improvement by researchers, while practitioners tend to retain an object role. The discourse and the implementation of actions are key components of the method. The boundary between science and practice becomes blurred in the actions.
- Responsive research: While distanced research seeks to improve theories (rational research notion), intervening research pursues the improvement of practice (rational practice notion). Responsive research leads to a continued exchange between science and practice whereby the practice – in contrast to action research – remains accountable for its actions and decisions.

Design research is regarded as a manifestation of responsive research, whereby the cooperation between science and practice is not a purpose in itself, but a means to increase the scientific and practical relevance of the interventions and/or theories. Including experienced practitioners in the various research and developmental phases should enable access to the particular field of practice's experience and perspectives, which will improve the quality of solutions and theories, and, thus, increase the probability that these "practicable" theories will be applied in practice.

Design research does not search for applications for existing research methods, but strives to find innovative solution approaches for practical problems (see SLOANE, 2013, 20). This characteristic is the initial basis for the requirement that the research practice's implementation should occur in different research process stages (see section 3). Depending on the stage, the cooperation can take on various forms and intensities, the practice response can range from commenting on scientific proposals to the testing of the agreed concepts and the adoption of individual process stages (see WAGNER, 1997, 17).

In the shape of design research, the principle of responsive research can be understood as the participating science and practice's specific stances; in concrete form, it is about activities in the context of the research process's outlined stages. With regard to the stipulated stances, it is, in essence, about the creation of conditions for an open, constructive, and trusting cooperative relationship. The following aspects may be relevant with regard to science (see EULER, 1994, 272ff.): disclosing the pursued objectives; developing a basis of trust; accepting different values and aims; clarifying target identities and conflicts; approaching a symmetrical discourse; taking the institutional framework conditions and its frequently heterogeneous interests, varying competencies, and divergent degrees of innovation commitment into account; and cultivating doubt and constructive criticism. The relevant references to science-practice cooperation were already provided in the explanation of the process phases in section 4.

Specifying problem	• Articulate and justify the relevance of specific challenges in practice • Contribute to defining a configurable and examinable problem • Activate available experience knowledge with regard to the framework conditions and options for a potential problem solution. • Synchronize the objectives and expectations of a design research project
Evaluating literature and experience	• Open the practice for field observations and the gathering of contextual knowledge • Validate initial suggestions about potential approaches to the development of solutions
Developing and refining design	• Engage in new, unusual approaches • Contribute and/or validate initial proposals for an intervention • Be willing to test the intervention
Testing design and evaluating it formatively	• Contribute to testing of the intervention • Reflect on and document the testing experience • Contribute to the development of alternatives to further improve the intervention
Generating design principles	• Validate the proposed design principles • Provide feedback on the application range and the limitations of the respective principles
Evaluating the intervention summatively	• Support the organization of access to a wider field of practice • Contribute to the validation of evaluation results

5 COMPLETION

Despite the comparatively detailed observations, many questions remain to be pursued by means of in-depth analyses and individual observations. These questions could be inherent to the concept, could transcend it, could be based on process phases or span them, could be based on practice cases, or be purely theoretically conceived. The following questions are only some examples:

- To what extent can a science-practice collaboration increase the scientific and practical relevance of the research?
- How important is the development in the context of design research and what makes it a design with scientific and practical claims?
- To what extent does design research lead to innovative practice improvements?

- How (exactly) does generalization and/or the generation of design principles occur within the context of design cycles?
- Which methods are useful for the generation of design principles and/or theories?
- What level of development has design research attained in the educational sciences and in other scientific disciplines?
- What “good examples” from design research offer a good basis for the further development of the paradigm?

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