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On the Ambiguous Nature of Theory in Educational Design-based Research – Reflecting and Structuring from an IS Perspective

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Abstract **Background:** The lack of commonly accepted models of educational Design-based Research (DBR) hinders the effectiveness of knowledge transfer and theory development in this field. DBR models are well-established in information systems (IS) research. The structured approaches to DBR in IS research have the potential to inform educational research practice for facilitating the interplay between theoretical and practical advancements.
Method: We compare existing approaches to identify compatibility in terms of objectives and structured process designs in the two fields based on a literature review. Having established common ground, we examine the role of theory as a result of DBR and identify potential for synthesis of existing models. Finally, we map a DBR Contribution Types Model from IS to educational

DBR and evaluate its applicability by reflecting on potential outcomes in this field.

Findings: We show a compatibility of the goals and characteristics of DBR in both disciplines and identify a common underlying understanding that enables an appropriation of concepts and models. The nature of DBR outcomes in educational research is found to be ambiguous, in particular with respect to the role of theory. This hampers the development of generalizable and transferable findings. DBR in IS provides perspectives on theory and processes which can foster DBR appropriation in educational research development and methodological validation. We show that DBR models in IS can inform the implementation of educational DBR.

Contribution: The paper contributes to the advancement of educational DBR by appropriating models developed in the context of IS research after thoroughly examining the compatibility of DBR in both fields. The more structured approach to examine and assess DBR outcomes enables to improve the generalisability and transferability of findings in educational research.

Keywords Design-based Research, Design Science, Design Theory, Contribution Types, Epistemology

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On the Ambiguous Nature of Theory in Educational Design-based Research – Reflecting and Structuring from an IS Perspective

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1.0 Introduction

Gaining knowledge in a deductive way through the development and evaluation of theories is a frequently pursued aim of educational research (Reinmann, 2005; Van den Akker, 1999). Although such knowledge can be of great relevance for solving practical problems in an educational context, the transferability of the research results to practice is often challenging. Empirical findings are usually not prepared for and directly transferable to application in educational settings (Anderson & Shattuck, 2012; Easterday et al., 2014), as classic empirical research does not aim to solve practical problems directly through the research processes (Reinmann, 2005; Van den Akker, 1999). Nevertheless, the need to strengthen research that pursues the development of practical solutions for current problems and challenges in educational practice through scientific methods is evident since decades (Edelson, 2002; Reinmann, 2005; Van den Akker, 1999).

Design-based research (DBR) as a meta-methodology (Anderson & Shattuck, 2012; Easterday et al., 2014) addresses the lack of applicability of classical empirical research findings by considering the development of solutions for problems in educational practice as a central goal of research (Edelson, 2002). DBR approaches aim to "improve practice" by working on problems in a "real educational context" (Anderson & Shattuck, 2012). At the same time, solving such practical problems should go hand in hand with theory building (Anderson & Shattuck, 2012; Barab & Squire, 2004; Cobb et al., 2003; Easterday et al., 2014; Edelson, 2002; Euler, 2014; McKenney & Reeves, 2014; Reinmann, 2005; Van den Akker, 1999). Reaching those goals needs the use of different scientific methods which is why DBR is characterised by a "methodological pluralism" (Rodríguez, 2017). The application of scientific methods concerns both the design process and the evaluation of the developed approaches for problem solving. Such scientifically grounded evaluations should lead to the development of transferable knowledge (Anderson & Shattuck, 2012; Barab & Squire, 2004; Cobb et al., 2003; Easterday et al., 2014; Edelson, 2002; Euler, 2014; McKenney & Reeves, 2014; Reinmann, 2005; Van den Akker, 1999).

Although there is a broad consensus on these overarching goals, there are different approaches to how to reach them and which requirements have to be met by the research results. Existing literature describes different process models, which lead to different types of results and different demands for generalisability (Easterday et al., 2014; Euler, 2014; McKenney & Reeves, 2014; Van den Akker, 1999; Wozniak, 2015). The dual objective of creating practical problem solutions and generating scientific knowledge leads to tensions and challenges in achieving a unified understanding of the demands for generalisability of the research results in DBR (Reinmann, 2017), or more generally, the "nature of its product" (Easterday et al., 2018). Easterday et al. (2018) state that "few have tried to address the nature of an educational intervention or precisely what kind of theories D[B]R produces […]." Furthermore, there is a need for a clear distinction of design processes in research and practice to reach scientific standards (Edelson, 2002). While Edelson (2002) describes "four features that distinguish design research from simple design" (research-driven, systematic documentation, formative evaluation and generalization), no models could be identified in literature so far that allow a structured classification of DBR results and their delineation from outcomes of design processes with respect to generalisability. Prior studies (e.g. Collins et al., 2004; Reinmann, 2017) have found that the lack of methodical standards and common models in the scientific literature hinders the establishment of DBR in educational research practice.

Attempts to explore the issue of the lack of commonly accepted models of educational DBR and to contribute to its resolution have not only been made from within the discipline (e.g. Bell, 2004; Easterday et al., 2018), but have also been undertaken via blending in external perspectives from other scientific fields, such as Cultural-Historical Activity Theory (CHAT) in a special issue in the Journal of the Learning Sciences (O'Neill, 2016). There, several contributions have addressed the dichotomous nature of DBR and the interplay and potential conflict between theoretical and practical advancements as research results (Cole & Packer, 2016; Greeno, 2016). This dichotomy is not only present in educational sciences, but has also been identified and discussed in other disciplines (e.g. Holmström et al., 2009; Lang, 2006; March & Vogus, 2010; Sandoval & Bell, 2004; Vaishnavi, 2007). In this contribution, we offer a perspective on this issue from Information Systems (IS) research. Design-based approaches have been extensively discussed in IS research in the last decades and are usually referred to as Design Science or Design Science Research (DSR). Integrating (IS-oriented) DSR and (educational) DBR has become a topic of interest in recent years in the emerging field of educational technology, where educational problems are addressed via the design of digitally supported instruments (e.g. Fahd et al., 2021). The scientific discourse on process models for conducting DBR and the dichotomy of theory and practice in DBR has also been extensively discussed in the field of IS (Goldkuhl, 2004; Gregor et al., 2020, 2020; Kuechler & Vaishnavi, 2012; Peffers et al., 2007; Walls et al., 1992), identifying similar issues as in educational DBR. The findings, challenges, and approaches to overcome them in both fields, however, have not been analysed and compared systematically so far, omitting the potential of advancing the status quo in either discipline by appropriation of models proposed in the respective other field. Appropriation here refers to a process of interpretation and re-contextualization of concepts, perspectives or methods proposed in one or another discipline (Alves Villarinho Lima & Almeida, 2021; Haapasaari et al., 2012). There appears to be potential for such appropriation, e.g. as the need for a common understanding of DBR results and their demands for generalisability mentioned in educational DBR is elaborated on in IS literature via "Design Science Research Contribution Types" proposed by Gregor & Hevner (2013).

In the context of educational DBR, different studies over several decades have called for a stronger focus on research in educational practice, the generalisability of its results and its potential to contribute to theory development (Brown, 1992; Collins et al., 2004; Easterday et al., 2014; Edelson, 2002; McKenney & Reeves, 2014; Reinmann, 2005; Van den Akker, 1999). The goal of this paper is to examine the potential for appropriation of DBR-models in the educational sciences and information systems research. Such an investigation contributes to the advancement of the status quo in educational DBR, if models proposed in IS research to address the dichotomy between theory and practice in DBR results can be successfully appropriated in educational DBR. This would help to better differentiate the scopes of research in educational DBR and support both, planning the overall research process including the determination of the requirements for the research results to be achieved and communicating the research project including the transferability of the findings, in a theoretically well-grounded way.

This article is structured as follows: as appropriation of models in both fields is only possible if the overarching goals and characteristics are compatible, we first compare the DBR approaches of both disciplines on a general level (section 3). Section 4 describes the results of DBR processes in both disciplines and introduces the model of "Design Science Research Contribution Types" proposed by Gregor & Hevner (2013). Section 5 aims to appropriate this model in an educational research context by assigning the educational DBR results identified in section 4. The paper closes with discussion of the potential and limitations of the model of Design Science Research Contribution Types in educational DBR.

2.0 Methodology

To examine the potential of appropriation of models from DBR in the IS and educational sciences, an initial literature review was carried out for both disciplines separately to assess the status quo. The database ERIC was primarily used to identify literature to educational DBR due to its focus on education science literature. Additionally, Google Scholar served as another resource to identify literature not listed under ERIC and to identify literature for IS research.

As mentioned in the introduction, the DBR approaches of both disciplines were first examined on a general level to assess their fundamental compatibility. Thus, the initial literature search and analysis focused on the goals and characteristics of DBR. The identified papers were analysed for each discipline separately before contrasting the findings.

The results of this comparison are presented in section 3. One major finding was that the characteristics of DBR manifest in how the research process is structured and organized.

In a second step towards answering the research question, we thus examined the DBR research processes with respect to their results presented in the identified literature in more detail. This examination, which is presented in section 4.1, showed that the results of educational DBR processes are described in partially vague, divergent, or even conflicting ways with respect to actors and steps to follow. Hence, we widened the scope of our literature review again to include articles that do not solely focus on DBR processes in order to examine whether DBR research results are examined more systematically in other studies. As described at the end of section 4.1, we could identify approaches that attempt to structure the different result types along their potential generalisability, but also leave room for interpretation with respect to the nature of the results.

An equivalent search approach was followed to identify literature for DBR in IS research. The literature analysis on DBR process models in this discipline showed that the highly cited and widely applied process model by Peffers et al. (2007) does not offer a differentiated debate about DBR results. Therefore, we also widened the scope of our review to focus on the results of DBR, even if not presented in conjunction with a process model. This search identified the Design-Science Research Contribution Types Model by Gregor & Hevner (2013), which has already been mentioned in the introduction. The model offers a structured and differentiated view on DBR results. We thus used this model as a frame of reference for examining the potential for appropriation of models developed in the field of IS-centric research in educational DBR. In our final step towards answering the research question, we examined the individual research results mentioned in the model of Gregor & Hevner (2013) in more detail to be able to assess their applicability to the results of educational DBR. In discussing the potential assignment of these results to the Contribution Types Model in section 5, we show both the conceptual and practical added value which such an appropriation can have, and demonstrate how it could inform the development of research process models that explicitly consider the dichotomy of research and practice in educational DBR.

3.0 Goals and characteristics of DBR

This section contrasts the goals and characteristics of DBR in educational sciences and IS research. This provides the foundation necessary to analyse the conceptual understanding of research results gained in DBR research processes in section 4. In the following, we first discuss the goals of DBR and then elaborate on its characteristics by examining the central activities of the research processes described in literature.

3.1 Goals of DBR

Educational Sciences:

Van den Akker (1999) states „that 'traditional' research approaches (e.g. experiments, surveys, correlational analyses), with their focus on descriptive knowledge, hardly provide prescriptions with useful solutions for a variety of design and development problems in education." Design-based research (referred to as "Development Research" by Van den Akker in 1999 and "Educational Design Research" in 2006) aims to close this gap and supports the development of innovation in practice by solving practical problems through scientific processes (Van den Akker, 1999; Van den Akker et al., 2006). Even earlier, Brown (1992) has pointed out challenges when aiming to integrate laboratory innovations into real classrooms and describes an approach to conduct design experiments. Even though different approaches exist that use different terms to refer to DBR (e.g. Design Experiments, Educational Design Research, Design Research, Design-based Research), they all pursue two fundament goals: 1) solving problems in educational practice through design-based research processes and 2) generating new (transferable) knowledge through the evaluation of the designed solution for contributing to theory development (Anderson & Shattuck, 2012; Barab & Squire, 2004; Cobb et al., 2003; Easterday et al., 2014; Edelson, 2002; Euler, 2014; McKenney & Reeves, 2014; Reinmann, 2017; Van den Akker, 1999). DBR projects necessarily have a longer-term perspective than one-off design projects to allow improving the developed solutions and "advance theoretical understanding" (Gunn & Steel, 2012).

Information Systems Research:

This understanding of DBR is compatible to the field of IS, as the statement of Gregor et al. (2020) shows:

> *"Design science research (DSR) aims to provide knowledge that has scientific legitimacy and also provides utility in achieving goals" (Gregor et al., 2020).*

Walls et al. (1992) provide a similar explanation to the purpose of DBR in the same domain. They state that the fundamental difference between "traditional" research approaches and DBR lies in the overarching objective of research: While natural and social science focuses mainly on describing existing phenomena, DBR projects aim to support reaching a goal directly through research processes (Walls et al., 1992).

Scientific IS literature over the years has developed seemingly divergent DBR approaches: On the one hand, a DBR understanding with a strong focus on knowledge acquisition and theory development (e.g. Gregor & Jones, 2007) and on the other hand, an understanding with a focus on development of design objects and problem solving (e.g. Hevner et al., 2004). To consolidate these two superficially different areas of consideration in scientific discourse, Gregor & Hevner (2013) have published a joint article. They state that the two approaches address "complementary rather than opposing perspectives" because both, generating new knowledge and solving practical problems have to be considered as objectives of DBR (Gregor & Hevner, 2013).

To sum up, solving a practical problem and gaining new knowledge about the solution to consider DBR in a different context than the original are the overarching goals of DBR in both disciplines. Thus, although different terms are used (also within the disciplines), our review suggests that what is referred to as DBR in the two disciplines is in principle compatible due to their correspondence with respect to its goal and outcome.

3.2 Characteristics of DBR processes

After having shown the compatibility of the goals of DBR approaches in educational and IS research, this section examines whether the common research objectives also lead to similar characteristics of the research processes.

Educational Sciences:
Several models proposed in educational literature address the activities of the research process: outlining a process of "analysis, design, evaluation and revision". Van den Akker (1999) describes four activities that are "iterated until a satisfying balance between ideals and realization has been achieved." McKenney & Reeves (2014) present a "generic model for design research" with three "main stages" including an "interaction with practice". They describe a flexible and iterative process including the activities "analysis/exploration", "design/construction", and "evaluation/reflection" (McKenney & Reeves, 2014). Wozniak (2015) adds conjectures about the effects of the design elements as a separate activity to the model of McKenney & Reeves. Euler (2014) describes similar but more differentiated activities in a "research and development cycle": The cycle presents the analysis of the underlying problem and the scientific literature in two phases that interact with each other. The evaluation is also considered in a more differentiated way. The cycle includes 1) formative evaluations of the prototype in an early stage of the research process for gaining information to improve the design and 2) a summative evaluation "after an advanced refinement" (Euler, 2014). The summative evaluation can lead to further problem analysis and iterative runs through the entire process again (Euler, 2014). The research model of Easterday et al. (2014) also outlines the phases of analysis, development, and evaluation. In contrast to the models mentioned above, Easterday et al. (2014) include the definition and consideration of the research aims in their process description.
The analysis of the different process models shows that all of them describe the activities "analysis", "development" and "evaluation" as core elements of a DBR process. The activities are usually implemented iteratively and flexibly until a satisfactory solution is developed and new knowledge is gained (where both "satisfactory" and "novel" largely remain vague concepts). The models differ in the

differentiation of the individual activities and the description of further steps. McKenney & Reeves (2014) conducted a literature review to identify common characteristics of DBR processes. They also identify the iterative and flexible character of the research process for problem solving and knowledge acquisition as the following list shows: DBR is …

- *"pragmatic because it is concerned with generating usable knowledge and usable solutions to problem solving […]*
- *grounded because it uses theory, empirical findings and craft wisdom to guide the work […]*
- *interventionist because it is undertaken to make a change in a particular educational context […]*
- *iterative because it generally evolves through multiple cycles of design, development, testing and revision […]*
- *collaborative because it requires the expertise of multidisciplinary partnerships, including researchers and practitioners, but also often others […]*
- *adaptive because the intervention design and sometimes also the research design are often modified in accordance with emerging insights […]*
- *theory-oriented not only because it uses theory to ground design, but also because the design and development work is undertaken to contribute to a broader scientific understanding" (McKenney & Reeves, 2014).*

Information Systems Research:
IS literature shows compatible activities with comparable characteristics in the Design Science Research (DSR) process:
Peffers et al. (2007) offer a model for supporting the implementation of DSR that has received wide attention and can be considered to be well-established and validated (Baskerville et al., 2018; Gregor & Hevner, 2013). They describe six activities of the research process: "Identify Problem & Motivation", "Define Objectives of a Solution", "Design & Development", "Demonstration", "Evaluation", and "Communication". The comparison with the models from educational literature shows that the core elements identified above "analysis", "development" and "evaluation" are also included in the model of Peffers et al. (2007). Their approach is also flexible and iterative with different entry points in the research process.

Adaptive and iterative processes are also described as characteristic for DSR by Venable (2006). Furthermore, he highlights an interplay of theory development, development of solutions for practical problems, and evaluation. Thus, the characteristics "pragmatic", "iterative", "adaptive", "interventionist", and "theory-oriented" proposed by

McKenney & Reeves (2014) are also considered relevant in conceptualizations proposed in IS research. Kuechler & Vaishnavi (2012) mention the inclusion of theories and practical knowledge in the design process to gain new knowledge through evaluation of the developed solution. The consideration of theory, practical knowledge, and findings from the evaluation are highlighted in various articles in IS literature (Goldkuhl, 2004; Gregor & Jones, 2007; Hevner, 2007). Thus, the characteristics „grounded" and „collaborative" as proposed by McKenney & Reeves (2014) also correspond to the descriptions of DSR in the field of IS.

To sum up, both the core elements and the associated characteristics from the educational DBR correspond to the concepts proposed in IS research. The description and analysis of this section show a conceptual compatibility between the disciplines, although the details and differentiation of the activities can vary in the different model proposals (even within one discipline).

This section has given an overview of the goals and characteristics of DBR in educational research and IS research and showed a common underlying understanding in both disciplines based on the reviewed literature. Demonstrating the compatibility of understanding was the necessary first step for examining the potential for appropriation of "Design Science Research Contribution Types" by Gregor & Hevner (2013) in the educational context.

4.0 Results of DBR processes

The fundamental compatibility of aims and processes in DBR in the two examined disciplines now allows to examine and compare the conceptual understanding of results of DBR from the perspective of both disciplines more closely. The first section takes up the educational DBR process models of the previous section to examine the associated research results. The second section focuses on the DSR results from an IS perspective focusing on the "Design Science Research Contribution Types" by Gregor & Hevner (2013). The last section brings the identified findings together and puts them in mutual context.

4.1 DBR results in educational sciences

DBR aims both to solve practical problems through the development of solutions and to gain new scientific knowledge (Anderson & Shattuck, 2012; Barab & Squire, 2004; Cobb et al., 2003; Easterday et al., 2014; Edelson, 2002; Euler, 2014; McKenney & Reeves, 2014; Reinmann, 2017; Van den Akker, 1999). The dual objective leads to tensions and challenges in achieving a common understanding of DBR results and the expectations on the generalisability of scientific knowledge gained through DBR processes (Reinmann, 2017). The process descriptions described in section 3 can lead to fundamentally different types of research outputs, as the following section shows.

Section 4.1.2 compares these types of outputs and focuses on the nature of scientific knowledge.

4.1.1 Results of educational DBR processes

Van den Akker (1999) describes "interventions" and "design principles" as potential outcomes of DBR. While an intervention "is especially oriented towards practical ends in a given situation", design principles "strongly reflect scientific scholarly aspirations" and correspond to "the major knowledge to be gained" through a DBR process. The term "intervention" comprises "products, programs, materials, procedures, scenarios, processes, and the like." Empirical testing of these interventions – usually through formative evaluation – allows to derive design principles (DP) that describe the "essential character of the intervention" as "heuristic statements" (Van den Akker et al., 2006). Van den Akker proposes a format for the formulation of design principles:

> *"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).*

Furthermore, he mentions that existing theoretical knowledge influences the design choices. The empirical testing of the designed intervention generates new theoretical knowledge with different scopes and generalisability:

> *"[…] these theoretical notions are usually referred to as 'mini'- or 'local' theories, although sometimes connections can also be made to 'middle-range' theories with a somewhat broader scope" (Van den Akker et al., 2006).*

McKenney & Reeves (2014) consider "maturing interventions" as a practical outcome and "theoretical understanding" as a scientific outcome of DBR in their generic process model. They refer to Van den Akker (1999) when highlighting design principles as "probably the most prevalent" kind of scientific outcome in DBR processes. Furthermore, they refer to different other kinds of theoretical knowledge such as descriptive or declarative knowledge produced by DBR. McKenney & Reeves (2014) use different examples from literature to illustrate the wide range of possible interventions (e.g. e-learning courses, learning games) and theoretical knowledge (e.g. design principles of online courses). They also claim that "generalisability" of findings is a particular challenge of DBR because

> *"educational design research takes place in natural settings where more variables are present than can be controlled for, the findings from these*

studies cannot yield immutable rules, easily transferred without consideration. […] when designs are tested in multiple settings and under varying conditions, or when design features are systematically varied under similar conditions, theory development can occur through analytic generalization" (McKenney & Reeves, 2014).

As noted in the previous section, Wozniak (2015) adds the concept of "conjectures" about the effects of the design elements to the model of McKenney & Reeves. Conjectures can "help to identify new areas of analysis and […] provide a clear rationale for making changes to the designed solution […], or guide further evaluation directions during the next iteration." They "can also focus later retrospective analyses to improve the trustworthiness of the outcomes […], namely the DPs and emergent theories" (Wozniak, 2015). This statement and the according process model show that Wozniak does not refer to interventions as key outcome of DBR. Rather, the "results from iterations", including the design of interventions, lead to the development of "design principles" and "theoretical understanding" as key outcomes of DBR (Wozniak, 2015).

The process model of Euler (2014) shows DBR results both as prototypes of interventions to solve practical problems and design principles based on the evaluation of the prototypes. He refers to the suggestion of Van den Akker (1999) for the formulation of design principles already mentioned above. According to Euler (2014), formative evaluations of the intervention in a cyclic process enable the generation of design principles. Finally, a summative evaluation may lead to the formulation of "consolidated design principles".

Easterday et al. (2014) visualize the DBR process by mapping the activities to be carried out. The process model focuses on showing how research processes of different scientific research methodologies can be incorporated "into design of another product such as an educational intervention" (Easterday et al., 2014). However, the results of the research processes are not specified in detail. The authors mention educational interventions and design principles as well as theories in the context of DBR results:

"We have defined DBR as a process that integrates design and scientific methods to allow researchers to generate useful educational interventions and effective theory for solving individual and collective problems of education" (Easterday et al., 2014).

In later works, they provide further explanations to the nature of DBR results: They describe DBR results as "products" including "arguments for how people should learn" (Easterday et al., 2018). Easterday et al. (2018) differ between "practical and theoretical products." While the former comprise "prototypes that promote learning in the real world", the latter

> *"are the representational design models describing how to design learning environments that help people learn. Design models take the form of blueprints that describe the necessary and sufficient characteristics of the learning environment and the causal mechanisms by which it promotes learning in a given context. These design models also include design arguments and mock-ups, which are supported by principles and frameworks that aid in the construction of design models that guide design" (Easterday et al., 2018).*

Design models arise from several iterations of the design process and should be transferable to other contexts. The main types of results that emerge from DBR as "theoretical products" are "design principles, patterns, and ontological interventions" (Easterday et al., 2018).

To sum up, the reviewed literature gives a heterogeneous picture of potential results of DBR: "practical interventions", "design principles", and "theories" are named as potential results (outcomes, products) of DBR processes. In particular, the role and nature of theoretical knowledge is ambiguous when taking a closer look at the different types of results of the research process, as the following section shows.

4.1.2 The role of theoretical knowledge in educational DBR

Although there appears to be a common understanding that the development and evaluation of an intervention provides the basis for gaining theoretical knowledge, the intervention itself is not considered as a result of DBR by all authors, like the article of Wozniak (2015) shows. Overall, while "interventions" are classified as practical outcomes in terms of prototypical problem solutions, both "design principles" and "theories" are assigned to scientific outcomes. However, there is an inconsistent picture with respect to the theoretical results that emerge from DBR as shown in the following.

Van den Akker (1999) mentions the possibility to develop theoretical knowledge as local or middle-range theories based on the evaluation of the intervention as a result distinct from design principles as the most prevalent outcome of DBR. McKenney & Reeves (2014) agree with Van den Akker that design principles are "probably the most prevalent" kind of scientific outcome. However, they also describe theoretical knowledge, such as descriptive or declarative knowledge, as a potential result of DBR. Wozniak (2015) highlights "emergent theories" as scientific outcomes again being distinct from the result type of "design principles". While Euler (2014) focuses exclusively on "design principles" as theoretical outcomes, Easterday et al. (2018) present "design models" as a broader approach that are informed by "design principles" and "frameworks". Furthermore, they highlight that "design principles, patterns, and ontological interventions" are preferred types of theories that emerge from DBR processes (Easterday et al., 2018).

Hence, the comparison of the approaches shows an inconsistent picture with respect to their understanding of theoretical DBR outcomes. Furthermore, the nature of theories and their connections to design principles remain largely vague and unresolved even within the approaches. The identified literature on DBR processes and their outcomes does not suggest a structured view or any consistent statements when referring to the nature of theoretical knowledge. By revisiting the results of our literature review, we thus widen the scope of our study to include articles that discuss educational DBR in a generic way, i.e. without explicitly focusing on the research process and its results. In this way two further studies could be identified that provide relevant perspectives on the role and nature of theory in DBR.

Edelson (2006) mentions that “the appropriate product for design research is warranted theory” in terms of a generalisable theory. In contrast to the approaches mentioned above, he gives a structured overview of “three kinds of theories that can be developed through design research” (Edelson, 2006):

1. *Domain theories* as “the generalization of a portion of a problem analysis” can be divided into two different types:
    - A *context theory* is a theory about a design setting, such as a description of the needs of a certain population of students, the nature of certain subject matter, or of the organization of an educational institution.
    - An *outcomes theory* describes the effects of interactions among elements of a design setting and possible design elements (Edelson, 2006).
2. *Design frameworks* as a “generalized design solution. It provides guidelines for achieving a particular set of goals in a particular context. A design framework rests on domain theories regarding contexts and outcomes” (Edelson, 2006).
3. *Design methodology* as “a general design procedure that matches the descriptions of design goals and settings to an appropriate set of procedures” (Edelson, 2006).

Edelson (2006) puts both “design frameworks” and “design methodology” in relation to the concepts of “design principles” as proposed by Van den Akker (1999). While the former correspond to “substantive design principles” (see section 4.1.1), the latter is described by Van den Akker (1999) as a set of “procedural design principles” (see section 4.1.1).

Another approach to structure theoretical knowledge gained through DBR comes from Gravemeijer & Cobb (2006). They state that DBR allows to develop “instruction theories” situated on three different levels:

1. “At the level of instructional activities (micro theories)
2. At the level of instruction sequence (local instruction theories)

3. At the level of the domain-specific instruction theory" (Gravemeijer & Cobb, 2006).

While Gravemeijer & Cobb (2006) focus on "instruction theories" as theoretical DBR outcome, Edelson (2006) additionally describes "domain theories" that have a declarative nature rather than an instructive one. In contrast, "design frameworks" and "design methodologies" correspond to principles that give prescriptions on how to do something for achieving a special goal (Edelson, 2006). Thus, design frameworks and methodologies are comparable to instruction theories based on Gravemeijer & Cobb (2006).

Summarizing, DBR aims to develop both problem solutions and new knowledge. While interventions as problem-solving approaches situated in a concrete context correspond to practical research outcomes, there is an inconsistent picture of theoretical knowledge that can arise through a DBR process: On the one hand, the evaluation of problem-solving approaches can lead to *prescriptive knowledge* (design principles, instruction theories, design frameworks, design methodologies) that includes instructions or principles on how to do something to reach a defined goal. Although these kinds of outputs should be transferable to other contexts, the identified literature does not describe how their generalisability can be assessed and described in a structured way. Thus, the question of what constitutes a theory in this context remains unclear due to a lack of consistent and structured view on prescriptive theoretical outcomes. On the other hand, DBR can also lead to the development of *descriptive or declarative knowledge* (McKenney & Reeves, 2014), which Edelson (2006) refers to as domain theories. These theories mainly focus on descriptions of observable phenomena identified through investigations in DBR projects, instead of prescribing of how to do something.

To conclude, literature on educational DBR offers a broad and diverse range of theories and theoretical knowledge gained through a DBR process. Although a high-level classification in two different kinds of knowledge (prescriptive knowledge/theories vs. descriptive or declarative knowledge/domain theories) can be identified based on the reviewed literature, the underlying concepts largely remain vague and are sometimes ambiguous, in particular in the area of prescriptive theories. There, the lack of systematic and consistent view of how different types of theories relate to each other with respect to their generalisability is evident, which leads to ambiguity when assessing the transferability of such DBR results.

4.2 DBR results in Information Systems Research

While the former section gave an overview of different approaches to results of DBR in the field of educational sciences, this section addresses the perspective of IS research. It focuses on the "Design Science Research Contribution Types" proposed by Gregor & Hevner (2013) as they provide a widely recognized and adopted structured view on Design Science Research results. We again review their proposed types of research, before we elaborate in more detail on the different perspectives on the nature of theoretical knowledge in DBR in the field of IS.

4.1.1 Results of DBR processes in Information Systems Research

In IS literature on DBR, the results of the research process are generally referred to as "artifacts". An artifact is often understood as something transferable into a material object (Goldkuhl, 2002) and often "ha[s] some degree of abstraction but can be readily converted to a material existence" (Gregor & Hevner, 2013). Simon (1996) states that artifacts "are synthesized […] by human beings […]" and "can be characterized in terms of functions, goals, adaption." In line with the research discipline, artifacts often manifest in the form of socio-technical systems such as decision support systems or modelling tools (Gregor & Hevner, 2013).

The term of Design-based Research is rarely used in the IS domain. Rather, the discipline is referred to as "Design Science", which aims to generate scientifically legitimated knowledge in addition to concrete problem solutions. Usually, the design, implementation, and evaluation of specific artifacts are the basis for knowledge generation in a "Design Science Research" (DSR) approach (Baskerville et al., 2018; Gregor & Hevner, 2013). The gained knowledge corresponds to "operational principles" or/and "design theories" that themselves are considered artifacts in IS research (Gregor & Hevner, 2013). Therefore, artifacts can manifest on different levels of abstraction which influences the "possibilities of generalizing" and therefore the transfer to other contexts. Such levels of abstraction can comprise design theories, operational principles, or specific instantiations of software (Gregor & Hevner, 2013). Hence, artifacts on different levels of abstraction represent distinct contribution types (i.e. results) of Design Science Research, as **Fehler! Verweisquelle konnte nicht gefunden werden.** illustrates.

Table 1: Contribution Types by Gregor & Hevner, 2013, p. 3

Design Science Research Contribution Types		
	Contribution Types	**Example Artifacts**
More abstract, complete, and mature knowledge	Level 3: Well-developed design theory about embedded phenomena	Design theories (Mid-range and grand theories)
↕ ↕ ↕	Level 2: Nascent design theory - knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1: Situated implementation of artifact	Instantions (software products or implemented processes)

Table 1 shows three possible levels of abstraction of artifacts as proposed by Gregor & Hevner (2013). The results of a research process can comprise one or more artifacts potentially on different abstraction levels. Artifacts are situated at level 1 when the contribution is some concrete "product" such as software that solves a concrete problem. Such artifacts do not offer any abstraction from their situated implementation and do not allow to explicate any underlying principles. Therefore, the possibility of transferring the artifact to other areas is very low. Level 1 artifacts are implemented to solve a particular problem in a particular context (Gregor & Hevner, 2013).

In contrast, artifacts on level 2 fundamentally are more abstract and are applicable to different contexts. Such artifacts describe underlying methods, constructs, design rules, or design principles. Gregor et al. (2020) identify different possibilities for describing design principles from literature. The starting point is the consideration that design principles should be useful to both practitioners and researchers. While practitioners need design principles for direct application in practice, researchers use them for knowledge generation, as the following quote illustrates:

> *"[…] design principles are used by implementers who apply them in practice and theorizers who use them to capture knowledge. The nature of these actors should be considered in the formulation of design principles, especially in terms of the principle's level of generality and whether decomposition to lower levels is needed to make it understandable by the intended audience. Providing a title or label for a design principle can assist in conveying the principle's main point"(Gregor et al., 2020).*

Thus, the target group must always be considered when formulating design principles to choose the appropriate level of abstraction. Design principles provide prescriptive statements and represent an important part of design theories, although they are not yet design theories (Gregor et al., 2020).

Artifacts on level 3 are referred to as "design theories". Design theories represent artifacts at the highest level of abstraction, which comprehensively describe phenomena that are investigated in the research process (Gregor & Hevner, 2013). Walls et al. (1992) define design theories as prescriptive theories:

> *"While explanatory theories tell 'what is', predictive theories tell 'what will be', and normative theories tell 'what should be', design theories tell 'how to/because"(Walls et al., 1992).*

The development of artifacts at a lower level of abstraction is the basis for theory development. This is followed by iterative steps in which generalisation can take place to generate increasingly abstract knowledge. The scope of design theories still can be limited – it is possible to develop parts of a theory or incomplete theories that are only applicable to a subset of the problem space (Gregor & Hevner, 2013).

To sum up the contribution types model by Gregor & Hevner (2013), all results of Design Science Research are artifacts situated on different levels of abstraction. The level indicates the demand for generalisability. While an artifact on level 1 is only applicable in a specific context, artifacts on level 2 and 3 include principles or instruction in the form of prescriptive knowledge that is transferable to other practical contexts. The next section examines the nature of theory based in IS literature in more detail.

4.2.2 The role of theoretical knowledge in IS Design Science Research

Gregor & Hevner (2013) use the term "theory" to refer to artifacts on level 2 and 3 in their contribution type model. While level 2 describes nascent theories in the form of operational principles, theories on level 3 represent "well developed design theor[ies] about embedded phenomena."

Gregor et al. (2020) highlight design principles as essential components of level 2 and level 3 artifacts. Their formulation differs in the level of abstraction and needs to be adapted to the intended target group. They propose a conceptual schema for design principles, as shown in Table 2.

Table 2: Scheme for design principles by Gregor et al., 2020, p. 23

Title: Design Principle Name	
Structure	**Components**
For **Implementer I** to achieve or allow **Aim A** for **User U**	Aim, Implementer, and User
in **Context C**	Context (Boundary conditions, implemention setting, further user characterisitcs)
Employ **Mechanisms** M1, M2, M3 ... involving **Enactors** E1, E2, E3, ...	Mechanisms (acts, activities, processes, form/architecture, manipulation of other artifacts) Subsidiary components/artifacts that can have their own design principles
because of **Rationale R**	Rationale Theoretical or empirical justification for the design principle

While the "implementer" translates the abstract design principle into a concrete design context, users are the people whose goals are to be achieved. The term "enactors" is typical for socio-technical systems. It describes who or what executes the mechanism – this can be a computer but also a person. For artifacts on the verge between level 2 and 1, the enactor can also be the user itself (Gregor et al., 2020).

Besides design principles, design theories should include further components for presenting prescriptive knowledge (Gregor & Jones, 2007):

- Purpose and scope of the theory
- Constructs or elements the theory consists of
- Artifact mutability
- Testable propositions (truth statements) about the design theory
- Knowledge sources (Gregor & Jones, 2007)

As the last point indicates, design theories are usually grounded in knowledge sources as “kernel theories” or “justificatory knowledge”: “A mature body of design knowledge should include kernel theory because such theory explains, at least in part, why the design works”(Gregor & Jones, 2007).
While “kernel theories” represent scientific knowledge from any IS discipline and theories, “justificatory knowledge” has a more informal character usually based on knowledge from practice (Gregor & Jones, 2007). Besides this theoretical foundation of design theories, the theory should be validated through empirical evidence and its internal cohesion and consistency (Goldkuhl, 2004).
Gregor (2006) describes design theory as one of five different kinds of theories in the field of IS. She proposes a taxonomy of theory types for explaining their attributes (see Table 3).

Table 3: A Taxonomy of Theory Types by Gregor, 2006, p. 620

A Taxonomy of Theory Types in Information Systems Research		
Theory Type		Distinguishing Attributes
I.	Analysis	Says what is. The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made.
II.	Explanation	Says what is, how, why, when, and where. The theory provides explanations but does not aim to predict with any precision. There are no testable propositions.
III.	Prediction	Says what is and what will be. The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations.
IV.	Explanation and prediction (EP)	Says what is, how, why, when, and what will be. Provides predictions and has both testable propositions and causal explanations.
V.	Design and action	Says how to do something. The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact.

Furthermore, Gregor (2006) presents the interrelationships among the theory types as Figure 1 shows.

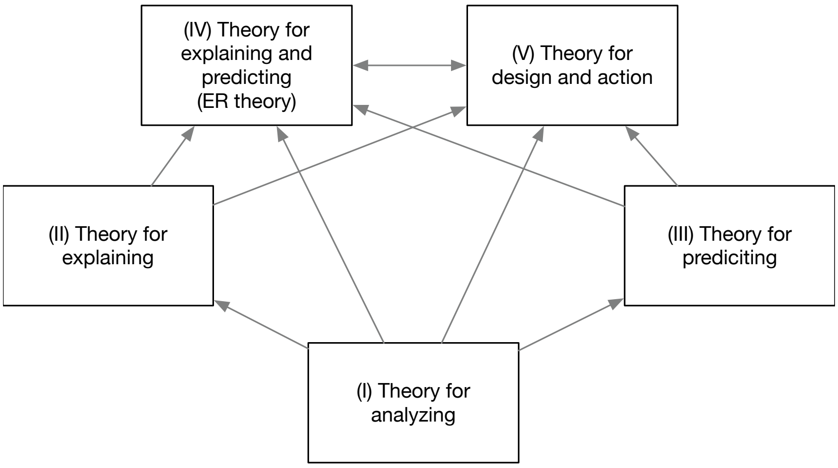

Figure 1: Interrelationships among the theory types by Gregor, 2006, p. 630

In the context of design theory, the following quote explains their interrelationships:

> *"Design theory can be informed by all other classes of theory. [...] Design theory and EP theory are strongly interrelated. Knowledge of people and information technology capabilities informs the design and development of new information system artifacts. These artifacts can then be studied in terms of EP theory: what impacts do the artifacts have in the work place and in society" (Gregor, 2006).*

Baskerville et al. (2018) refer to the theory types by Gregor (2006). They highlight that design science "looks for prescriptive type 5 theory (theory for design and action), and not necessarily types 1 to 4" (Baskerville et al., 2018).

Even if prescriptive knowledge in the form of a design theory represents a research contribution in the current IS research (Baskerville et al., 2018; Gregor, 2006), historically there used to be different perspectives on theoretical contribution types: March & Smith (1995) highlight constructs, methods, models, and implementation as outcomes of design science. However, they mention the term theory only in the context of the natural science research. A similar approach was taken by Hevner et al. (2004) in their early research. They described different contributions without focusing on theory development. This approach has changed in more recent publications, as the "Design Science Research Contribution Types" (Gregor & Hevner, 2013) mentioned above shows. Additionally, different other authors support the view that a design theory represents theoretical contributions of Design Science (Baskerville et al., 2018; Goldkuhl, 2004; Gregor & Jones, 2007; Simon, 1996; Walls et al., 1992).

In general, there are different views on theory depending on "philosophical and disciplinary orientations" (Gregor, 2006). Based on a review on different perspectives on theory, Gregor (2006) comes to the conclusion that theories are

> *"[…] abstract entities that aim to describe, explain, and enhance understanding of the world and, in some cases, to provide predictions of what will happen in the future and to give a basis for intervention and action" (Gregor, 2006).*

Although "generalisation" represents essential requirements on theories, there are different approaches with respect to the level of generalisation, the breadth of focus and the boundaries of theories (Gregor, 2006).

To sum up, design theory is one type of theory in IS research. It represents prescriptive knowledge that Design Science Research approaches primarily aim to develop. Design theories are usually grounded in a knowledge base (kernel theory, justificatory knowledge) and consists of design principles. Design principles are a key requirement for theoretical knowledge gained through a DSR process. Based on their level of abstraction, they are referred to as nascent design theories or as well-developed design theory.

4.3 Comparison and Synthesis

This section provides an overview of the understanding of DBR results and the role of theory therein from the perspective of educational sciences and IS research. In the former section we have outlined the approaches for each discipline separately in order to enable a comprehensive overview. This section brings the approaches of the two disciplines together in an analytical way and identifies commonalities and differences.

Educational Sciences:

Section 4.1 has demonstrated the heterogeneous picture of educational DBR results, where there is ambiguity and vagueness with respect to which types of knowledge can be gained in a DBR process. The literature analysis allowed to identify two fundamental types of knowledge that can emerge through a DBR process: On the one hand, McKenney & Reeves (2014) and Edelson (2002) describe that a DBR process can lead to new *descriptive or declarative knowledge* (according to Edelson: *domain theories*) that describe and/or explain naturally occurring phenomena observable through investigations in DBR projects. On the other hand, Edelson (2006) and Gravemeijer & Cobb (2006) highlight *prescriptive knowledge* (design principles, instruction theories, design frameworks, design methodologies) as an outcome of DBR that includes instructions or principles on how to do something to reach a defined goal. There is, however, none of the established conceptualization of how these different kinds of prescriptive knowledge relate to each other, in particular with respect to their generalisability. Additionally, the ways to produce the different types of theoretical knowledge is not described consistently in the reviewed process models.

Information Systems Research:

In IS research, Gregor (2006) presents five different types of theories (theory for analysing, explaining, predicting, explaining and prediction, design and action) that are relevant in this field. In general, theories are defined as “abstract entities” with the goals of their application depending on the theory type (Gregor, 2006). Baskerville et al. (2018) refer to these theory types and state that design science “look for prescriptive type 5 theory (theory for design and action)” and not necessarily for the other types. According to these findings, DSR can involve the application of different types to theories, with the primary goal of developing design theories that represent prescriptive knowledge. To structure the different possible outcomes, Gregor & Hevner (2013) present the model of “Design Science Research Contribution Types” that classifies DBR outcomes based on their level of abstraction. According to the model, all outcomes of a DBR process can be described as artifacts situated on different levels of abstraction. Thus, concrete, situated interventions, more generic design principles, and prescriptive theories (design theories) are all artifacts and possible results of DBR (Gregor & Hevner, 2013).

Comparison & Synthesis:

Comparing the approaches proposed in the two disciplines shows that both describe prescriptive knowledge and other types of knowledge as possible theoretical DBR outcomes. While IS literature highlights design theories (including design principles) as primarily expected theoretical DBR outcomes (without explicitly excluding other types of theory), educational literature lacks this clear focus on prescriptive theories. Although the identified authors mention design principles as theoretical knowledge gained through DBR processes (Easterday et al., 2018; Edelson, 2006; Gravemeijer & Cobb, 2006; McKenney & Reeves, 2014; Van den Akker, 1999; Wozniak, 2015), an inconsistent and partly vague picture arises when different authors use the term “theories” or further theoretical knowledge that refer to results that go beyond design principles. Nevertheless, educational literature presents prescriptive knowledge in the form of design principles as a theoretical DBR outcome that is comparable to prescriptive knowledge in IS.

Based on the previous findings, prescriptive knowledge is a typical and the primary outcome for DBR, which sets it apart from other research approaches. The type of theory that can be derived from DBR depends on the research focus and the “philosophical and disciplinary orientation” (Gregor, 2006) so that further theoretical knowledge gained through DBS can vary according to the research context. DBR in IS research in general and the presented “Design Science Research Contribution Types” focus exclusively on prescriptive knowledge (see section 4.2.1) and provide structure to an aspect that is left particularly vague and ambiguous in educational DBR. Hence, in line with the research question of this work, examination of the potential for appropriation of the model now focuses on prescriptive knowledge gained through DBR.

5.0 Appropriation of models

The former section gave insights into the perspectives of DBR results focusing on the different kinds of theoretical knowledge in the field of educational and IS research. Since the identified educational literature provides an incoherent picture on which types of theoretical results can be achieved and how they relate with each other, this section examines whether the "Design Science Research Contribution Types" by Gregor & Hevner (2013) can be used to enable a more concise while differentiated consideration.

To examine the appropriation in the educational context, we re-examine all approaches to characterise DBR outcomes as described in section 4.1 and map them to the model by Gregor & Hevner. Table 4 visualises this mapping in an extended version of the table describing the "Design Science Research Contribution Types" as proposed by Gregor & Hevner (2013).

Table 4: Contribution Types by Gregor & Hevner (2013) extended by Educational DBR Outcomes

Design Science Research Contribution Types extended by Educatinal DBR Outcomes			
	Contribution Types	**Example Artifacts**	**Educational DBR Outcomes**
More abstract, complete, and mature knowledge	Level 3: Well-developed design theory about embedded phenomena	Design theories (Mid-range and grand theories)	**Middle-range theories?** (van den Akker, 1999) **Domain-specific instruction theory?** (Gravemeijer & Cobb, 2006)
	Level 2: Nascent design theory - knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.	**Design principles** (van den Akker, 1999; McKenney & Reeves, 2014 Wozniak, 2015; Euler, 2014; Easterday et al., 2014) **Mini- or local theories?** (van den Akker, 1999) **Emergent theories?** (Wozniak, 2015) **Local instruction theories?** (Gravemeijer & Cobb, 2006) **Design frameworks and design methodogogy?** (Edelson, 2006)
More specific, limited, and less mature knowledge	Level 1: Situated implementation of artifact	Instantions (software products or implemented processes)	**Interventions** (van den Akker, 1999; McKenney & Reeves, 2014; Euler, 2014; Easterday et al, 2014) **Micro theories?** (Gravemeijer & Cobb, 2006)

Level 1 of Table 4 shows a broad agreement among the authors from the identified educational literature to interventions as outcomes of

DBR processes. Only Wozniak (2015) deviates from this understanding: Wozniak describes the development and implementation of interventions to gain scientific insights from their evaluation without presenting the interventions themselves as a scientific result. Overall, interventions in an educational context are, for example, “products, programs, materials, procedures, scenarios, processes” (Van den Akker, 1999). Their implementation aims to solve practical problems and thus represents practical outcomes of DBR processes. This approach corresponds to level 1 by Gregor & Hevner (2013), which comprises “situated implementations of artifacts”. Artifacts on that level are concrete products designed for specific contexts, or – in other words – they provide a specific solution to a problem. Since an artifact on level 1 is designed for a specific context, no claim of generalisability can be made for this type of outcome (Gregor & Hevner, 2013). In educational literature, Gravemeijer & Cobb (2006) describe the development of instructional theories at three different levels. They refer to “micro theories” as “instructional activities” assigned to level 1 in the contribution model. The question mark in the table indicates an uncertainty with this assignment. Although the description indicates a match to level 1, it is not clear if Gravemeijer & Cobb would consider their “micro theories” to be an artifact at level 1 based on Gregor & Hevner (2013)’s characterization. In turn, Gregor & Hevner (2013) do not refer to level 1 artifacts as “theories”.

Level 2 of Table 4 shows that design principles are considered a key outcome of educational DBR. Van den Akker (1999) states that design principles correspond to “the major knowledge to be gained” through a DBR process and McKenney & Reeves (2014) define them as “probably the most prevalent” kind of scientific outcome of DBR. There is also a broad agreement that design principles are defined and refined based on formative evaluations of the implemented interventions. Furthermore, Euler (2014) emphasises the need for a summative evaluation to specify consolidated design principles in his process model. “Knowledge as operational principles” is situated on level 2 in the contribution type model of Gregor & Hevner (2013). An artifact on level 2 is applicable to different contexts by describing underlying methods, constructs, design rules, or design principles (Gregor et al., 2020). Thus, design principles describe more abstract knowledge than interventions on level 1. Artifacts on level 2 are referred to as “nascent design theories” because they can form the basis for the emergence of theories, although they are not yet design theories (Gregor et al., 2020). In educational literature, there are different statements on which types of theories can be developed through a DBR process. Requirements on these theories in terms of their level of abstraction and generalisability often remains unclear or vague. Van den Akker (1999) mentions “mini- or local theories” and Wozniak (2015) considers “emergent theories” as possible scientific outcomes in an educational DBR process. Since they provide no detailed information about their understanding of these kinds of theories, it is not sure that their mentioned theories are semantically equivalent to “nascent design theories” situated on level 2 of the model of Gregor & Hevner (2013). It even remains unclear if they refer to prescriptive or descriptive theories. In contrast, Gravemeijer & Cobb (2006) mention “local instruction theories” as one level in their three-level model of developing domain-specific theories. Thus, these theories clearly have a prescriptive character as it is the case with the theorectical contribtions described by Gregor & Hevner (2013). The description indicates a compatibility to level 2 of the contribution type model, although the explanations in the article entail some uncertainty in this classification.

Level 3 of the table represents artifacts at the highest level of abstraction and comprehensively describe phenomena investigated in the research process (Gregor & Hevner, 2013). These design theories are defined as prescriptive theories that describe “how to/because” (Walls et al., 1992). Although there is a high expectation on the generalisability of such artifacts, they do not necessarily have to be comprehensive and complete theories with respect to their scope (Gregor & Hevner, 2013). Gregor et al. (2020) highlights design principles as part of design theories situated on a more abstract level. As mentioned above, different authors from educational literature describe theories as DBR outcome, too (Easterday et al., 2014; McKenney & Reeves, 2014; Van den Akker, 1999; Wozniak, 2015). However, it remains unclear if their understanding of a theory developed in a DBR process corresponds to prescriptive theories. Additionally, the requirements on the different kinds of theories are not clearly described. Thus, an exact mapping to level 3 or 2 is difficult to conduct. As described above, “mini or local theories” (Van den Akker, 1999) and “emergent theories” (Wozniak, 2015) could correspond to level 2 because of their attributions “local” and “emergent”. In contrast, “middle-range theories” by Van den Akker (1999) have a broader meaning and could correspond to level 3. However, it remains unclear if the “middle-range theories” represent prescriptive theories or refer to other types of knowledge. In contrast, Gravemeijer & Cobb (2006), who focus on “domain-specific instruction theories”, clearly indicate the prescriptive character of this DBR result. Based on the explanations, compatibility with level 3 is probable. Easterday et al. (2014) and McKenney & Reeves (2014) focus on design principles when highlighting prescriptive knowledge as DBR outcome. There is no indication that they refer to design theories on level 3 of the model by Gregor & Hevner (2013). The table represents the remaining uncertainties by question marks to show that the explanations in the literature do not allow an exact classification and assignment.

Overall, Table 4 shows that the educational DBR outcomes described in the literature can be assigned to the model of Gregor & Hevner (2013) in principle. Nevertheless, the vagueness of the descriptions in the respective articles does not allow a clear classification of all mentioned DBR results due to ambiguities in terms of the nature of theoretical knowledge and the level of abstraction. These uncertainties are not only a challenge for the present study. They rather lead to uncertainties in the research process itself because it remains unclear which kind of results can be expected from different research processes that are described for DBR in educational literature. This not only leads to limited acceptance of the overall research approach, but also makes the communication of the results difficult, since it is not possible to clearly indicate the scope of the external validity of the results. The adoption of the contribution type model can help to avoid these ambiguities through a classification of the intended and achieved results and also allows to describe more comprehensive and concise research process models that enable to explicitly plan DBR that incrementally progresses from situated problem solutions to generically applicable design theories.

6.0 Discussion and Conclusion

In educational literature, researchers highlight the need for developing and evaluating innovations through design-based research in educational practice (e.g. Brown, 1992; Collins et al., 2004; Easterday et al., 2014; Edelson, 2002; McKenney & Reeves, 2014; Reinmann, 2005; Van den Akker, 1999). However, a lack of methodical standards and common models in scientific literature hinder the establishment of the DBR research approach in educational sciences (Collins et al., 2004; Reinmann, 2017). This is different in research disciplines like Information Systems (IS) Research (Peffers et al., 2007), where the DBR approach is more broadly accepted. This paper has aimed to contribute to overcome these issues and addressed the lack of unified understanding and models to DBR results and their demands for generalisability in the educational research literature. To this ends, it has examined the potential for appropriation of the "Design Science Research Contribution Types" model by Gregor & Hevner (2013) in the educational context to contribute to overcome the lack of models and standards to characterise educational DBR results.

Our results show that both disciplines follow similar aims with compatible elements and associated characteristics. Although using different terms, DBR aims to solve practical problems and gain new knowledge through an iterative and flexible research process. This new knowledge can take different forms, referred to intervention, design principles, and theories when describing possible results of educational DBR processes. The nature of theoretical knowledge, however, remains vague in the analysed literature. While DBR in IS has a clear focus on prescriptive knowledge, educational sciences largely do not distinguish between different types of theories. Furthermore, the relationship between the different result types remains vague and ambiguous with respect to its generalisability – an aspect that has also been addressed more explicitly and clearly in IS research. Therefore, the "Design Science Research Contribution Types" by Gregor & Hevner (2013) has been used to structure DBR results described in educational sciences. The evident vagueness of theoretical outcomes described in educational literature led to some cases where results could not be clearly assigned. Nevertheless, the mapping showed that the model is useful to offer a comprehensive classification of educational DBR outcomes.

The model allows a structured view of potential DBR outcomes that helps both planning and conducting the research process. It is necessary to clarify what outcomes are being sought to use appropriate scientific methods throughout the research process based on the targeted level of abstraction. Furthermore, the classification of the research results based on their level of abstraction facilitates their communication and assessment of the validity of the results. Through the application of the model, it becomes evident that the development and evaluation of a specific intervention requires other research methods such as overarching principles. Furthermore, the model shows that specific interventions developed and evaluated through scientific methods can be considered to be relevant and valid research results, even if no claim on generalisation can be made yet. As Gregor & Hevner (2013) state, the development and evaluation of an artifact at a lower level of abstraction is the basis for theory development through further DBR research activities in which generalisation can take place. Educational research emphasises that longer-term research projects are necessary to improve problem solution and "advance theoretical understanding" (Gunn & Steel, 2012). The model by Gregor & Hevner (2013) enables the classification of the different results obtained in the entire research project, clearly indicating what readers can and should expect when considering to transfer the presented results to another practice context.

To conclude, this paper showed that the model of "Design Science Research Contribution Types" by Gregor & Hevner (2013) from IS research is applicable also for the educational context. It offers a structured view on different kinds of DBR results including their demands for generalisability. However, the use of the model is limited to results of prescriptive nature, such as descriptions of concrete interventions or prescriptive theories derived from them. The model does not cover further theoretical insights that go beyond prescriptive knowledge in the research process. Based on the findings of this paper, further research can be conducted on models that include other types of theories in addition to prescriptive theories.

This paper dealt with the appropriation of a model originating in IS research to educational DBR based on literature analyses and theoretical considerations. It still lacks a comprehensive review of the model's applicability to educational research practice. In this sense, this article is to be considered a first step towards more mature and structured DBR in educational sciences and provides the basis for further research to verify the value of the model in its application for actual educational DBR.

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