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Title [From Messy Processes to Structured Approaches: Refining and Adapting the Decision Map for the Initial Generation of Design Principles](#)

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Abstract Design principles (DP) play a central role in Design-Based Research (DBR) as a key mechanism for linking theory development and practical design. Although their importance is widely acknowledged, the early phase of their initial generation is often described as methodologically unclear. To address this challenge, Althoff et al. (2025) proposed a Decision Map to structure key decisions preceding the initial formulation of DP. Building on this work, the present article aims to refine and adapt the Decision Map in order to provide more explicit guidance for this critical phase of DBR. The study draws on a retrospective comparative analysis of three completed DBR projects in geography education. The analysis focuses on (1) the role of design processes prior to DP formulation, (2) the contribution of these early

phases to theory development, and (3) the influence of context-specific project parameters. Based on these insights, the Decision Map is revised by integrating exploration phases and context-specific parameters as overarching framing elements and by strengthening its connection to theory development. The refined Decision Map offers a more differentiated and transparent heuristic for structuring the initial generation of DP especially for novice DBR researchers.

Keywords Design-Based Research, Exploration Phases, Design Processes, Design Principles, Initial Generation of Design Principles

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From Messy Processes to Structured Approaches: Refining and Adapting the Decision Map for the Initial Generation of Design Principles

Johannes Keller, Marcel Barth, Julia Polten

1.0 Introduction

Design-Based Research (DBR) is gaining increasing significance in (geography) education, as the approach is specifically aimed at linking theory development with its transfer to classroom practice (Feulner et al., 2021; McKenney & Reeves, 2019; Schmidt & Serwene, 2026). Through this dual output, DBR represents an important approach for addressing practical problems and establishing innovations in school practice. To achieve this, prototypes are developed, evaluated, and revised in iterative cycles (McKenney & Reeves, 2019). Central to the transfer between theoretical and practical knowledge are design principles (DP) (Euler, 2014a; Feulner et al., 2021). They translate existing or newly generated insights into design guidelines, design criteria, action guidelines, or design rules for practical application (Althoff et al., 2025). Consequently, they are essential to the dual output of DBR projects and serve as a central quality standard (Feulner et al., 2021).

Despite their pivotal role in the DBR discourse within geography education, the broader literature offers little concrete guidance on how DP are initially generated (Euler, 2014b; Feulner et al., 2021). In general, this process has often been described as “messy” and remains methodologically unclear (Hanghøj et al., 2022). To support DBR researchers during this challenging phase, different models were developed. Hanghøj et al. (2022) developed a heuristic model with five guiding questions to develop, apply and evaluate DP. Focusing on the initial generation of DP, Althoff et al. (2025) have developed a Decision Map for this challenging phase. This map systematically outlines relevant decision fields as well as exemplary procedures and decision options for the initial generation of DP (Althoff et al., 2025).

While the Decision Map provides an important first step toward increasing transparency in the initial generation of DP, the extent of its practical guidance remains unclear. In retrospect and informed by new insights from international literature, three major limitations become apparent. Firstly, Althoff et al. (2025) position the initial generation of DP as preceding the design of the prototype. Nevertheless, their work illustrates how design processes in exploration phases influence the initial generation of DP and shows that the development of these principles cannot always be separated from the design process. However, this relationship is not further specified and therefore needs to be elaborated further. Secondly, despite the acknowledged relevance of

DP for theory development (Serwene et al., 2024), the Decision Map does not clarify how to structure this process in early stages of DBR. Lastly, while Althoff et al. (2025) contend that the initial generation of DP is influenced by the specific context of a DBR project, they do not systematically elaborate on the role of such contextual parameters.

Against this background, the overall aim of this article is to revise and adapt the Decision Map presented in Althoff et al. (2025), drawing on international literature and comparative reflections conducted after the authors had completed their DBR projects. Subsequently, the Decision Map is refined and adapted to address the identified weaknesses. Finally, the application and limitations of the Decision Map are discussed.

2.0 The Decision Map

For the development of the Decision Map in Fig. 1, both general DBR literature and illustrative examples, mostly from geography education, were consulted. Based on those insights, three decision fields were derived from the literature: identification of a knowledge base relevant to the research subject (1), selection of knowledge for the transfer into DP (2), and presentation and formulation of DP (3). These decision fields cover key decisions DBR researchers need to make regarding the initial generation of DP (Althoff et al., 2025).

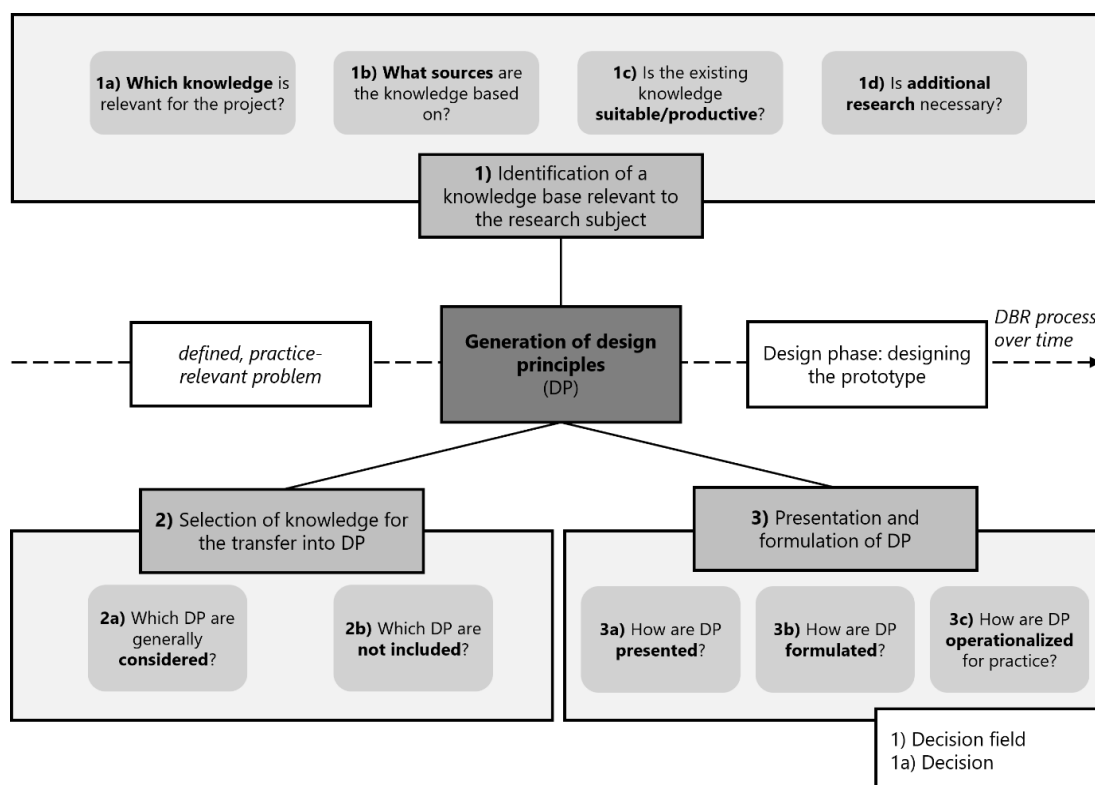


Figure 1: Simplified and translated version of the Decision Map from Althoff et al. (2025) with only the decision fields and decisions.

As shown in Tab. 1, Althoff et al. (2025) describe how the three authors of the present article outlined their individual procedures for each field during the initial development of DP within their PhD DBR projects. By

analysing and comparing these approaches, example decisions for each decision field were formulated. These examples are intended to support researchers during the initial generation of the DP, but they are not exhaustive (Althoff et al., 2025).

Table 1: Example procedures for different decision fields from the three DBR projects (translated from Althoff et al. (2025)).

Keller's project	Polten's ¹ project	Barth's project
Decision: 1) Identifying the Knowledge Base for the DP Decision field: 1b) Knowledge sources		
<ul style="list-style-type: none"> Collection of additional empirical knowledge in a multi-step exploration phase through project days and exploration cycles. Knowledge from the literature, but no systematic review. 	<ul style="list-style-type: none"> Collection of experiential knowledge from geography teachers experienced in key concepts. Conduct of an additional empirical study. Knowledge from literature, but no systematic review. 	<ul style="list-style-type: none"> Collection of experiential knowledge through three exploration cycles. Knowledge from literature, but no systematic review.
Decision: 2) Selection of Knowledge for Transfer into DP Decision field: 2b) Criteria for excluding knowledge as DP		
<ul style="list-style-type: none"> Conflicts with practice-related project parameters. No added value for didactic research. 	<ul style="list-style-type: none"> Contradictions in the knowledge base. Lack of relevance to the research goals. Conflicts with practice-related project parameters. Conflicts with research-related project parameters. Overly general or non-specific. 	<ul style="list-style-type: none"> Contradictions in the knowledge base. Conflicts with insights from the exploration phase. Overly general or non-specific.
Decision: 3) Presentation and Formulation of DP Decision field: 3b) Linguistic formulation of DP		
<ul style="list-style-type: none"> Main DP: formulated as goals; subordinate levels: specifications for achieving the goals. Full sentences using modal verbs ("should" sentences). 	<ul style="list-style-type: none"> Formulated purely as design criteria without justification or goals. No strict adherence to a formulation scheme. Main DP: bullet points; subordinate levels: full sentences with some bolding of keywords. Passive constructions. 	<ul style="list-style-type: none"> See Project Key Concepts (Polten) Suggestion sentences using modal verbs ("should" sentences).

¹ Née Althoff

3.0 Retrospective Analysis of Decisions Made

To refine and adapt the Decision Map, its shortcomings were first elaborated based on existing literature. For each weakness, the aspects requiring clarification were formulated in guiding questions. Retrospectively, these questions were then answered for the three DBR projects (Tab. 2). Afterwards, the procedures were compared and discussed to inform the revision of the Decision Map. For a better understanding, a brief overview of the projects, their status during the development of the Decision Map and their current status is presented in Tab. 2.

Table 2: Brief description of the three DBR projects with current status and status during the development of the Decision Map.

<p>Digital Geo-Media (Johannes Keller)</p>	<p>Content: Digital geo-media such as satellite imagery or web-map applications are important tools for spatial analysis in geography education. For example, the combined use of satellite imagery and field excursions enables students to analyse spaces from multiple perspectives (Keller et al., 2024a). However, there is a lack of practical tips for teachers and few materials to support this approach, a gap that should be closed using the DBR approach. It is important, on the one hand, that the combined use creates added value for students by overcoming disadvantages or enabling the combination of different data sources. On the other hand, digital geo-media must be used in the context of the key concepts (Keller & Siegmund, 2026a). These assumptions form the basis for DP that have been evaluated and further developed in various studies with a DBR approach based on Reinmann (2020) and Feulner et al. (2021) (Keller et al., 2024b; Keller & Siegmund, 2026a, 2026b).</p> <p>Status During Development of the Decision Map: First part of exploration phase was finished (Keller et al., 2024b) and exploration cycles started (Keller & Siegmund, 2026a). Only main DP were formulated but were completely revised after finishing the exploration cycles.</p> <p>Current Status: completed, corresponding doctoral thesis is in print.</p>
<p>Project Key Concepts (Julia Polten)</p>	<p>Content: Topics such as anthropogenic climate change, population growth, and biodiversity loss are among the most pressing challenges of our time and are integral parts of the subject of geography. Since their influencing factors are part of highly differentiated systems with multiple interactions (Ohl, 2013), these topics exhibit significant factual complexity (Bögeholz & Barkmann, 2005), making their teaching and learning extremely challenging (Ohl, 2013). An approach to addressing this complexity is the promotion of conceptual learning. This is pursued in subject didactics through so-called key concepts (Fridrich, 2016), defined as "fundamental [...] central ideas of disciplinary thinking that can be found in various geographical phenomena" (Fögele & Mehren, 2021, S. 50, translated by the authors). Examples in geography include the human-environment system, various spatial concepts, or the sustainability square (Fögele, 2016). While there are numerous indications in the literature of the great potential of conceptual teaching (Fridrich, 2016), there are still many uncertainties regarding its practical implementation, which have been raised both in academic discourse and by practitioners (Fögele, 2016). To address open questions on implementation, this DBR-based project examined how conceptual learning, using the example of the</p>

	<p>key concept of the sustainability square, can be practically promoted in student learning. To this end, a conceptual teaching unit on the topic of sustainable consumption was developed and implemented, researched, and optimized over two DBR cycles.</p> <p>Status During Development of the Decision Map: one of the two main cycles was finished</p> <p>Current Status: completed, the corresponding doctoral thesis has been defended.</p>
<p>Project Ethical Judgement (Marcel Barth)</p>	<p>Content: Many topics in geography education, especially those related to education for sustainable development and global learning, are characterized not only by factual but also by ethical complexity (Ohl, 2013). To address this ethical complexity in geography teaching, didactic research has long focused on moral judgment competence, where the (moral) attitudes of learners are central to the analysis (Meyer & Felzmann, 2010). Only in recent years have contributions emerged that criticize the focus of this approach on value ethics and possible relativism, advocating instead for understanding the ethical problem within the subject matter of geography (Barth & Ullrich-Riedhammer, 2023; Ulrich-Riedhammer, 2017). Ulrich-Riedhammer (2017) calls for a questioning approach to understanding ethical problems, which she describes as “ethical judgment in geography education” and defines as “distinction within ethical questions” (Ulrich-Riedhammer, 2017, S. 106, translated by the authors). However, little is known about the practical implementation of such ethical judgment in geography education, and thus there are few prototype teaching units. The aim of this project was to use DBR to develop context-independent design criteria for teaching and learning environments for high school geography students.</p> <p>Status During Development of the Decision Map: Exploration cycles and one of the two main cycles were finished (Barth & Ullrich-Riedhammer, 2023).</p> <p>Current Status: completed, corresponding doctoral thesis is in preparation.</p>

3.1 The Role of Design Processes

Central to DBR is the design process, through which a deeper understanding of a problem and a viable solution are simultaneously developed. This process operates in a tension between creative–exploratory and deliberate, planned action (Reinmann, 2025). However, the role of DP within this process remains unclear. While some models view DP as outcomes emerging from iterative cycles of development and evaluation, others propose formulating them as heuristic assumptions prior to creating an initial prototype (Easterday et al., 2018; Feulner et al., 2021; McKenney & Reeves, 2019). Despite these differing positions, there is broad consensus that design decisions in DBR must always be informed, theoretically grounded, and transparently documented (Easterday et al., 2018; Reinmann, 2025). DP can provide an important contribution to meeting these requirements (Feulner et al., 2021).

In the model proposed by Feulner et al. (2021), DP serve as a mechanism for integrating theoretical assumptions into practical design work. To achieve this, they are formulated ahead of the formal design process on several operationalisation levels. While the first stage of DP are more closely tied to theoretical foundations, the final stages are more practice-oriented. This multi-level structure enables a systematic and traceable translation from the knowledge base into practice (Feulner et al., 2021). In examples based on this model, all operationalisation levels were formulated prior to the design process (Hiller, 2017). Nevertheless, exploration phases to test existing design and to gain practical or empirical knowledge play a key role in this approach (Althoff et al., 2025; Feulner et al., 2021).

Althoff et al. (2025) similarly locate the initial generation of DP ahead of prototype development. However, they also indicate that the design process during exploration phases can influence the initial generation of DP and that this process gradually merges with the development of the prototype (Althoff et al., 2025). Consequently, these early design activities warrant closer examination, as they meaningfully influence the generation of DP. To this end, it needs to be clarified which design activities took place before or during the initial generation of the DP, how these activities influenced the DP, and how the first prototype was designed (Tab. 3).

Table 3: Design processes carried out before or during the initial generation of DP and development of the prototype.

Keller's project	Polten's project	Barth's project
What design processes happened before and during the initial generation of DP and why were they conducted?		
<ul style="list-style-type: none"> ● Two-stage exploration phase, in which teaching materials were developed and evaluated (Keller et al., 2024a; Keller et al., 2024b; Keller & Siegmund, 2026a). ● One part of the exploration phase was a DBR project, in which DP were generated after iterative evaluation and revision of teaching material (Keller & Siegmund, 2026a). ● Wish to structure knowledge through the design process and assess how design works. 	<ul style="list-style-type: none"> ● No relevant design processes happened before the initial generation of DP. 	<ul style="list-style-type: none"> ● Conducting three exploration cycles in own teaching practice. ● Using existing materials for the initial exploration cycle; subsequently developing new materials based on insights gained from the first exploration cycle. ● Exploration cycles were used to supplement the literature base with practical knowledge and to test ideas.

How did design processes influence the initial generation of DP?

<ul style="list-style-type: none"> ● Exploration phase was used to collect empirical and practical knowledge for initial generation of DP. ● DP were developed based on best-practice experience during exploration phase as well as to avoid problems with developed materials (Keller & Siegmund, 2026a). ● Best-practice examples derived from the teaching materials developed in the exploration cycles constitute the final stage of the DP operationalisation. 		<ul style="list-style-type: none"> ● Exploration phase was used to collect empirical and practical knowledge for initial generation of DP. ● DP were developed based on best-practice experience during exploration phase ● Best-practice examples derived from the teaching materials developed in the exploration cycles constitute the final stage of the DP operationalisation.
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How was the initial prototype designed?

<ul style="list-style-type: none"> ● Development of materials during the exploration phases (Keller et al., 2024a; Keller et al., 2024b) ● Development of the prototype for the main study after exploration cycles (Keller & Siegmund, 2026a, 2026b). 	<ul style="list-style-type: none"> ● Prior to the initial generation of the DP, no design processes in the sense of exploratory phases were conducted; however, preliminary research was carried out to generate additional knowledge for the DP ● No exploration cycle(s) ● Development of the prototype based on the DP previously generated through literature and empirical approaches ● The prototype aimed to implement the initial DP as closely as possible; it was developed from scratch rather than drawing on existing materials 	<ul style="list-style-type: none"> ● Using existing materials for the initial exploration cycle (Mehren & Ulrich-Riedhammer, 2021) ● Adaptation of the prototype after exploration cycles
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- Final stage of DP were formulated after development of the prototype

Across all three DBR projects, the procedural logic largely followed the framework proposed by Feulner et al. (2021), according to which DP are formulated prior to the main research cycles. To gain sufficient knowledge for the initial generation of DP, exploration phases were conducted in all three projects. These included various empirical studies as well as exploration cycles following a DBR logic. Keller's and Barth's main focus was the generation of practical knowledge, as they considered this to be insufficient for the initial development of DP. Polten, on the other hand, wanted to close knowledge gaps and integrate practical knowledge from teachers (Althoff et al., 2025).

Keller's and Barth's projects involved extensive exploration cycles aimed at generating empirical and practice-based knowledge. Within these phases, both researchers iteratively designed and revised teaching materials following DBR principles: Barth primarily adapted existing materials and complemented them with newly developed ones, Keller developed new materials and refined them across several iterations. In both cases, the exploration phases formed the basis for the subsequent initial generation of DP. Keller and Barth used this approach not only to supplement literature-based knowledge but also to test and refine emerging ideas. In the course of this process, both researchers developed novel approaches to addressing their respective practical problems (Barth, 2022; Keller & Siegmund, 2026a). For this purpose, a theory-driven design process without the explicit formulation of DP initially proved to be more effective. The final operationalisation stage described by Feulner et al. (2021), target-group-specific concretization, was realized through best-practice examples derived from the materials developed during the exploration cycles or from their adaptations.

By contrast, Polten's project followed a different trajectory. Empirical data were generated through two studies with teachers and students (Althoff & Hase, 2024). In combination with literature-based knowledge, these findings served as the primary foundation for the initial development of the first three stages of DP. The design processes began only thereafter. To this end, the second stage of DP was put into practice. Once the teaching material was developed, the fourth stage was used to explain how the second stage was operationalised.

In summary, design processes preceding the initial development of DP are not a prerequisite for successful DBR projects. Rather, it became apparent that such processes were used to generate the empirical and practical knowledge required for the initial formulation of DP. Since this knowledge includes both empirical and practice-based insights, design processes proved to be a suitable means of generating it. At the

same time, Polten's project demonstrates that alternative approaches can also be used to generate relevant knowledge.

3.2 Theory Development

A central goal of DBR is the (further) development of theories through the iterative evaluation and refinement of prototypes. Those new theories or theory elements should provide solutions for the selected practical problem. Given the nature of the practical problem, no existing theory can be assumed to provide a direct solution. Consequently, innovative solutions must be developed by translating theoretical, empirical, and practical knowledge into prototypes (Althoff et al., 2025). Following the model proposed by Feulner et al. (2021), this process is guided through the initial development of DP.

To develop DP literature-based, empirical and practical knowledge needs to be transferred into DP. To this end, existing theories may be adopted, abstracted, specified, further developed, transferred, generalized or interconnected (Prediger, 2015). The nature, quality, and fit of a theory determine whether and how it can be creatively adapted or directly adopted (Prediger, 2015; Serwene et al., 2024). Accordingly, it is important to consider whether a theory is prescriptive or prognostic, explanatory or descriptive, or normative in nature (Prediger, 2015). On the other hand, different forms of knowledge could also be transferred to initial theories, which could be useful to structure theory development (Serwene et al., 2024).

Following Prediger's (2015) argumentation, theories for further development can be adopted from literature or newly developed. To this end, four types were suggested, ranging from developing them based on practical knowledge, through adaptation from other disciplines, to interconnecting different theories (Prediger, 2015). For example, (Feulner, 2020) adapted the well-established self-determination theory by (Ryan & Deci, 2020) for her initial DP to develop an innovative instructional design. Within the DBR cycles, this design was subsequently evaluated with regard to its effectiveness. In contrast, Hiller (2017) translated theories from multiple domains into several DP, a step that was necessary due to the multidimensional nature of the practical problem. As a result, different theories were interconnected during the theory development (Serwene et al., 2024). However, it is not always required to rely exclusively on literature-based theories. As demonstrated by the project of Serwene (2023), initial theories informing the initial development of DP can also be derived from empirical findings or practical experience.

The Decision Map of Althoff et al. (2025) emphasizes the role of the three types of knowledge (literature-based, empirical, and practical) in identifying the knowledge base in the first decision field. It also points out that knowledge to be transferred into DP needs to be selected. However, the Decision Map does not provide structured guidance on how to connect these steps to theory development. It remains unclear how to select theories for development of DP. These unresolved aspects were retrospectively compared in Tab. 4 across the three projects to examine how these steps were carried out.

Table 4: Examples for initial theories and theory development in the three DBR projects.

Keller's project	Polten's project	Barth's project
What example theories were relevant for solving the practical problem?		
<ul style="list-style-type: none"> ● Main theory: Geographical key concepts as a structuring aid for geographical thinking (Fögele, 2016). ● Furthermore, multiple theories and empirical results from different areas of geography education and other subject didactics were useful, e.g. about the role of visualizations (Hmelo-Silver et al., 2017), teaching conceptual knowledge (Fögele & Mehren, 2021; Serwene, 2023) or instructional design models (van Merriënboer, 2020). 	<ul style="list-style-type: none"> ● Of particular importance were existing theoretical considerations on teaching with geographical key concepts (Fögele & Mehren, 2021). ● Furthermore, theories on ESD (Haan, 2007, 2008) as well as psychological theories (e.g. Sweller & Chandler, 1991) were incorporated. 	<ul style="list-style-type: none"> ● Main theory: ethical judgment in geography education (Ulrich-Riedhammer, 2017) ● Additional theories derived, for example, from the field of moral psychology, such as moral sensitivity (Rest, 1986), or from other subject didactics concerned with judgment in subject-specific instruction
How were theories used to develop DP?		
<ul style="list-style-type: none"> ● Main theory was selected as key to solving the practical problem. However, it was insufficient to develop DP. ● Exploration cycles were used to gain empirical and practical knowledge how the main theory can be used, using elements from existing theories ● DP were synthesized based on the results. They specify how the main theory can be applied based on other theories and empirical insights. 	<ul style="list-style-type: none"> ● Main theory was partly insufficient for the development of DP. ● Other theories were sufficient for development of DP (e.g. theories on ESD), while theories about students' conceptions about sustainability were missing. ● Research was conducted to close knowledge gaps. ● Sufficient theories/theory elements in combination with additional research was used for the initial development of DP. 	<ul style="list-style-type: none"> ● Existing solution based on the main theory proved to be unsuitable for educational purposes. ● Based on the main theory new ideas were developed and tested in exploration cycles. In this step other theories were incorporated. ● Once the proposed solution was deemed satisfactory, initial DP were generated.

Why were theories selected for further development and which theories were not selected?

<ul style="list-style-type: none"> ● Research Gap: Main theory was not applicable to analyse satellite imagery. ● Some theories were not chosen for further development (e.g., deep structures) to keep research focus. However, those theories still affect the design. 	<ul style="list-style-type: none"> ● Research Gap: implementation of teaching with geographical key concepts ● Some theories (e.g., on ESD) were used as a foundation for the initial generation of the DP; however, further development of these theories was not pursued due to their established nature and existing level of differentiation 	<ul style="list-style-type: none"> ● Research Gap: methodological implementation of ethical judgment in geography education ● Some theories were not selected for further development (e.g., ethical language competence) in order to maintain the research focus and due to the substantial additional data volume, that would have required analysis. However, those theories still affect the design.
<p>Were initial theories formulated?</p>		
<ul style="list-style-type: none"> ● No explicit formulation of initial theories for development of DP ● Initial Theories were implicitly formulated in Keller und Siegmund (2026a) 	<ul style="list-style-type: none"> ● No explicit formulation of initial theories for development of DP ● Initial theories are implicitly formulated in the theoretical section of the dissertation 	<ul style="list-style-type: none"> ● No explicit formulation of initial theories for development of DP ● Initial theories were implicitly formulated in Barth (2022)

Across all three DBR projects, a single theory initially served as the central foundation for the development of DP and, consequently, for addressing the respective practical problem. However, the comparative analysis presented in Tab. 4 shows that in none of the projects was the selected main theory sufficient on its own to guide the development of robust DP. Keller and Polten reflected this insufficiency during the development of the knowledge base. In Barth’s project, it emerged during classroom implementation. None of the researchers used the functions or structural characteristics of theories to evaluate them (Prediger, 2015).

To address these limitations, the authors systematically integrated additional sources of knowledge. These included literature-based theories from related domains as well as newly generated empirical and practice-based insights derived from exploration phases. In this context, theories and knowledge from adjacent fields and other subject didactics were integrated.

The selected main theory in each project framed a specific research gap. In each case, existing main theories were further developed to allow their practical application for educational purposes. This aim was defined prior to the initial generation of DP. Other theories were not

selected for further development in order to narrow the research focus, manage the volume of data, or because the respective theories were already well established and sufficiently differentiated. Nevertheless, complementary theories played a crucial role in the development of DP. Elements drawn from these additional theories were used to adapt, specify, or operationalise the main theory in relation to the practical problem.

In all three projects, different knowledge types were synthesised in DP. However, none of the authors explicitly formulated initial theories. Instead, the theoretical elaboration underlying the DP remained implicit, embedded in the synthesis of theoretical assumptions, empirical findings, and practical considerations.

In summary, it became evident that the early stages of DBR play a crucial role in theory development. To this end, a research gap was identified, and a decision was made on how to address this gap. In all three projects, existing theories were further developed for this purpose. Alternative approaches are outlined by Prediger (2015) and Serwene et al. (2024). In addition, initial measures for theory development were taken. Existing gaps were addressed either by drawing on established theories or through exploratory phases. In the latter case, empirical and practical knowledge was collected. In all three projects, the available knowledge base was synthesized prior to the derivation of DP, even though no explicit initial theories had been formulated.

3.3 Context-Specific Parameters

Beyond the specific content of a DBR project, the project's context can influence DP at various levels. This includes research-related project parameters, practice-related project parameters, and the nature of theory-practice collaborations, which are an essential part of DBR.

Research-related project parameters refer to conditions arising from the scientific context of the project. These could include time constraints (e.g., duration of externally funded projects), human resources (whether they are run by a single researcher or a larger team), financial resources (the available budget), or mandatory project requirements (e.g., objectives in externally funded projects).

Practice-related project parameters refer to conditions inherent to the practical context or demands arising from it. In this case, the practical context refers to the setting in which the design will be tested. Examples of conditions could include required alignment with the prescribed curriculum, the size of learning groups, technical equipment available, or adherence to common practices (routines, didactic principles, etc.). Obczovsky et al. (2024) argue that these factors influence how theory can be used in the design process and recommend a pragmatic implementation.

The cooperation between researchers and practitioners is a key characteristic of DBR (McKenney & Reeves, 2019), with varying forms of interplay between these perspectives (Aigner & Malmberg, 2022;

Reinmann, 2025; Serwene, 2024). Through the collaboration of both sides, the focus on theory building as well as the practical relevance of DP can be ensured, which later DP mostly lack (Sales & Ferreira, 2025). However, these collaborations can also influence the initial generation of DP. As outlined by Sloane (2010), theory-practice collaborations can be used to select knowledge to be transferred into DP. In this approach, theorists develop workshops for teachers, which the teachers use to experiment with innovations. The reflections of both the teachers and the theorists are then used to cyclically further develop the workshops (Sloane, 2010). On the other hand, different goals and agencies of researchers and practitioners can also influence the second and third decision field (Buhl et al., 2022). Additionally, power imbalances between researchers (Willer et al., 1997) or in theory-practice collaborations (Schreiber & Ghafoor-Zadeh, 2022) can affect both the selection of knowledge to be transferred into DP and the way they are formulated.

Another way to integrate practical and theoretical knowledge is to conduct DBR projects while assuming a dual role. Particularly during the design and redesign phases, this dual role, such as acting simultaneously as researcher and practitioner, can be perceived as beneficial, as it allows instructional materials to be tailored more precisely to the specific needs of the learner group. On the other hand, such a dual role may require increased justification, especially concerning the legitimacy of acting in personal union and the scientific rigor of the research project (Serwene et al., 2025). In such dual roles, it is essential that researchers critically reflect on their own position within the DBR project (Aigner & Malmberg, 2022).

In summary, researchers should be aware of the specific context of their project, as these factors may influence decision-making during the initial generation of DP. Particularly, the research-related and practice-related parameters as well as the nature of collaboration with other researchers and practitioners are relevant. However, Obczovsky et al. (2024) argue for a pragmatic approach during the DBR to keep DBR feasible. In the Tab. 5, those aspects were described in an exemplary manner for the three research projects.

Table 5: Example of the influence of research- and practice-related parameters and the nature of cooperations on the initial generation of DP.

Keller's project	Polten's project	Barth's project
What were the research-related parameters?		
<ul style="list-style-type: none"> ● The research-project was embedded in a three-year externally funded project. ● The use of an app ("BLIF:Explorer") as well as 	<ul style="list-style-type: none"> ● The dissertation project was embedded in a time-limited funding scholarship. 	<ul style="list-style-type: none"> ● Research began as an external dissertation alongside full-time employment as a teacher at a high school.

<p>the subject-specific content for the project days was predefined in the project.</p> <ul style="list-style-type: none"> • Due to time constraints, a comprehensive literature review was not conducted; instead, a topic-specific literature search was carried out. 	<ul style="list-style-type: none"> • The topic and research interests of the project were fixed, but there was flexibility in the details. • Due to time constraints, a comprehensive literature review was not conducted; instead, a topic-specific literature search was carried out. 	<ul style="list-style-type: none"> • Dissertation was a follow-up project of another dissertation. • This research project was not part of an externally funded project. • No external financial or time-related constraints • The dual role of the researcher offered the opportunity to conduct low-barrier exploratory cycles and carry out research.
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What were the project-related parameters?

<ul style="list-style-type: none"> • DP should be applicable during a project day or in regular classroom settings (with 20–30 participants and lessons of 45 or 90 minutes) • DP must comply with curricular requirements and should not require technology that is not available in schools • No prior knowledge of students and teachers about satellite imagery must be taken into account 	<ul style="list-style-type: none"> • DP should be applicable in regular classroom settings (with 20–30 participants and lessons of 45 or 90 minutes) • DP must comply with curricular requirements and should not require technology that is not available in schools • The developmental product (a conceptual teaching unit) must be designed so that it fits methodologically and didactically into “everyday” teaching 	<ul style="list-style-type: none"> • DP should be applicable in regular classroom settings (with 20–30 participants and lessons of 45 or 90 minutes) • DP must comply with curricular requirements and should not require technology that is not available in schools • DP need to consider the didactic guidelines established in the school context, such as competency-based teaching and research findings from educational psychology (motivation, interest, etc.).
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What is the nature of the cooperation between researchers and practitioners?

<ul style="list-style-type: none"> • Personal union between researcher and practitioner. Full-time job at university, only limited teaching experience. • The theory-practice collaboration in the project was based on unstructured exchanges before and after 	<ul style="list-style-type: none"> • Exchange with practitioners in the context of conducting expert interviews, from which insights for the development of the DP were derived. • Generation of the DP by the author herself; collabora- 	<ul style="list-style-type: none"> • Personal union between researcher and practitioner, works at both university and school • Additionally, during the exploration phase, exchanges with other experts took place to discuss the generation of the DP.
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the project days during the exploration phase. The DP were formulated by the researcher alone.

rative work with practitioners on optimizing the implementation of the DP in the teaching unit.

- The teaching unit was conducted not by the researcher but by practitioners.

Both Keller's and Polten's projects were embedded within time-limited research frameworks. In these cases, the topics and research interests were shaped by specific project objectives (Keller) or by general conditions set by the scholarship (Polten). These research-related parameters directly influenced the scope and content of the developed teaching units, thereby guiding the formulation and direction of DP. For instance, Keller's project was subject to explicit requirements regarding the mandatory use of an app and satellite imagery, which determined the structure and operationalisation of DP. In contrast, Barth's project was not constrained by external project parameters. Instead, the DBR project emerged from a practical problem identified in the preliminary study. While this problem setting also influenced the development of DP, the parameters were derived intrinsically from the research question itself rather than from external project conditions.

Due to time constraints, neither Keller nor Polten conducted a comprehensive literature review to identify the relevant knowledge base. In contrast, a literature review was unnecessary in Barth's project, as it was built upon a previous dissertation that had already established the research and literature context. However, Barth also faced time constraints, which arose from the dual burden of teaching full-time at a high school while simultaneously conducting a DBR project. Nevertheless, this dual role provided him with the opportunity to conduct low-barrier exploratory cycles and carry out research.

What all three research projects have in common is that new teaching concepts for regular school instruction were developed. Therefore, the teaching materials created must be usable in regular classroom teaching, consider curricular requirements, and implement general didactic principles (e.g., clarity, relevance to everyday life).

The theory-practice collaboration during the initial generation of the DP varied across the three projects. In the Digital Geo-Media project, feedback from teachers was collected in an unsystematic manner during project days in the exploration phase. Polten gathered practical knowledge from teachers through interviews and collaborated with teachers in delivering the teaching unit, while Barth worked as a teacher, thus taking on the dual role of practitioner and researcher. This dual role entails both opportunities and challenges. In order to reflect on and become aware of each role within the research process and to ensure transparency, Barth employed the dual pearl model

from Aigner und Malmberg (2022) for reflection. All three projects target both theory-development and output for teachers, which was considered in the implementation of the DP (Althoff et al., 2025).

In all three research projects, additional research was necessary, as the literature-based knowledge was considered insufficient. This opportunity was used in all three projects to initiate first theory-practice collaborations. For example, this included the collection of experiential knowledge during project days (Keller), expert interviews with teachers (Polten), and generating experiential knowledge/empirical data through exploration cycles (Barth/Keller) (Keller & Siegmund, 2026a). Polten and Keller also conducted additional studies (Althoff & Hase, 2024; Keller et al., 2024b).

While Sloane (2010) calls for a theory-practice cooperation to design what knowledge should be transferred in DP, the authors made this decision by themselves. E.g., in Polten's project contradictions arose between interviewed teachers, which required a decision to be made. Yet, a decision in this early stage of the DBR process is not necessarily final, as discarded options can be implemented in a later cycle.

4.0 New Version of the Decision Map

The original version of the Decision Map proposed by Althoff et al. (2025) provides a clear and systematic structure for organizing key steps that precede the initial development of DP. However, a retrospective analysis of the three projects reveals that several critical moments within this early phase were only implicitly addressed or remained under-specified. Against this background, the analysis highlights opportunities to revise and extend the Decision Map in order to provide more explicit guidance for navigating these crucial steps in this particularly critical phase:

In particular, our findings show that design processes prior to the initial formulation of DP are typically situated within exploration phases (Feulner et al., 2021). Within these phases, DBR cycles or other approaches to Research Through Design are especially suitable for generating context-specific empirical and practical knowledge (Reinmann, 2025). However, they are not mandatory, as alternative pathways for generating such knowledge were also identified. While exploration phases are most closely linked to decision field 1 (identifying the knowledge base), their outcomes influence all subsequent decision fields. To account for this overarching role, the revised Decision Map explicitly incorporates “exploration phase” as a framing element that surrounds and informs the entire decision-making process rather than being tied to a single decision field (Figure 2).

To strengthen the contribution of DBR to theory development, it seems valuable to focus this contribution on the Decision Map. Across the analysed projects, it became evident that even early stages of DBR are important for theory development. To this end, several steps seem

to be important. Firstly, a research gap should be identified, and decisions be made about which paths of theory development fit to the DBR project (Prediger, 2015). To structure this process more systematically, it may be crucial, when building the knowledge base, to explicitly identify which theories are relevant (Prediger, 2015). Assessing their function and structure could be useful to identify knowledge gaps. This decision is added in the first decision field. Due to the role of exploration phases for theory development, this is also added within the frame of the Decision Map (Fig. 2).

For the generation of DP, it is relevant to synthesize the knowledge base and select knowledge to be transferred into DP. To this end, different knowledge types from the knowledge base need to be considered. Although initial theories were not used in the analysed projects, we suggest that the formulation of initial theories could be helpful for this step. This step could also help to increase transparency (Serwene et al., 2024). Consequently, we added this in the second decision field. Lastly, all three projects indicated that especially the decision 3c) is closely linked to the design phase. To take this into account, a connection between these two aspects is added.

Lastly, our analysis showed that various context-specific parameters affect the initial development of DP. These include research-related parameters, practice-related parameters, as well as the nature of cooperation between researchers and practitioners. To systematically account for these influences, we incorporated them as framing elements in the revised Decision Map as displayed in Fig. 2.

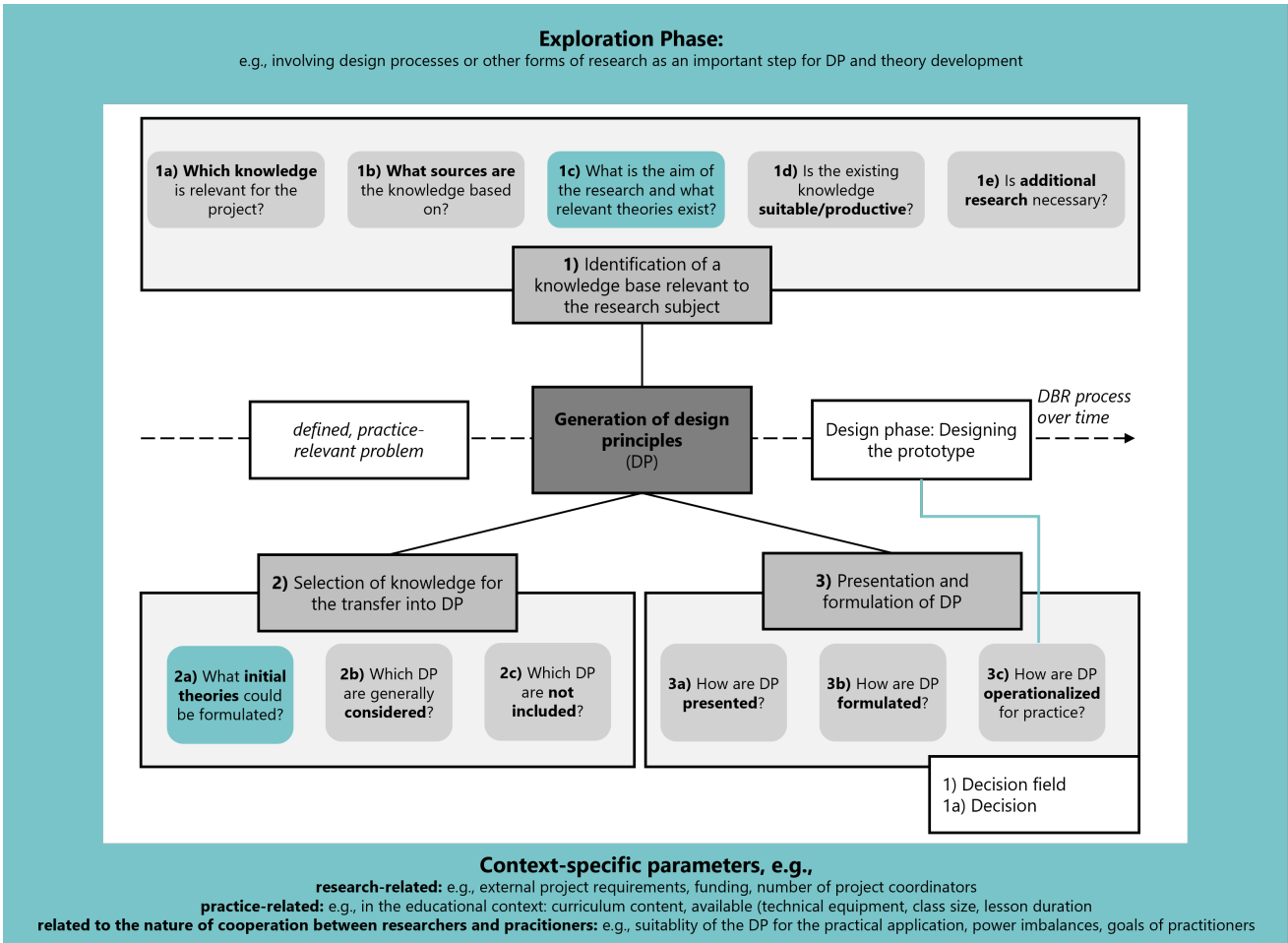


Figure 2: Refined and adapted version of the simplified Decision Map with the three decision fields and the frame in which those decisions need to be made (adapted from Althoff et al. (2025)).

5.0 Discussion

The overall aim of this study was to refine and adapt the Decision Map by Althoff et al. (2025) to better support research during a crucial phase of DBR. To achieve this, the identified weaknesses of the Decision Map were examined in detail. Through a retrospective comparison of how the authors approached early design processes, developed theoretical insights, and addressed context-related parameters, the original Decision Map was adapted to overcome these limitations. However, the Decision Map itself does not constitute a full DBR model; rather, it highlights a specific yet highly relevant aspect within DBR projects. In the following, its application within existing DBR models and its limitations will be discussed.

According to the Decision Map, the initial generation of DP is temporally situated between the explication of the initial problem and the first design phase of the development product (Althoff et al., 2025). Thus, despite the inherent oscillations within the decision fields and the fluid transition into the design phase (see Section 3.1), the Decision Map is somewhat static (Althoff et al., 2025). Consequently, it fits well with the process model for DBR from Feulner et al. (2021), with its clearly structured phases from DP generation, design, etc. In such a model, the Decision Map can provide a crucial step toward structuring the process, encouraging researchers to engage in the initial generation of DP before the design process begins, and allowing for informed design decisions and transparent documentation. Against this background, we argue that the Decision Map can also be used in structural models like the Research-Through-Design (RTD) model displayed in Fig. 3 (Reinmann et al., 2024).

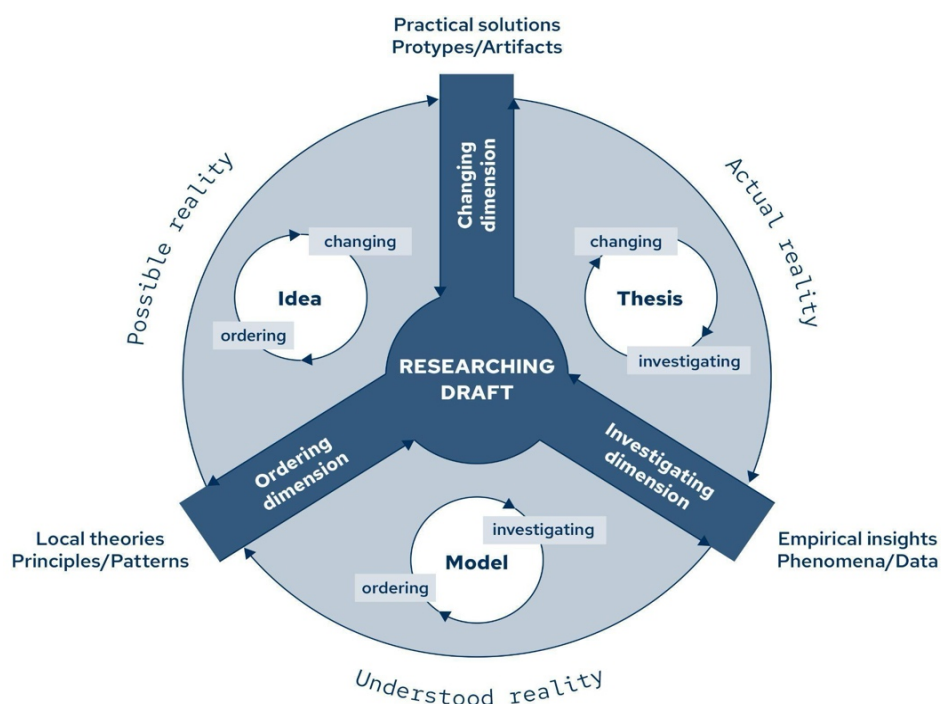


Figure 3: The RTD Model with its three dimensions (Reinmann et al., 2024; translated by the authors)

In the RTD model by Reinmann et al. (2024), the design process takes center stage, consisting of an ordering, a transforming, and an investigating dimension. The iterative character of DBR projects emerges through the oscillation between any two of these dimensions (Reinmann et al., 2024). Between the ordering and transforming dimensions, ideas are intended to emerge and be translated into prototypes. Between the transforming and investigating dimensions, testable hypotheses should be formulated, which can then, in the final possible oscillation, be developed into models and theories. Although DP are not explicitly mentioned here, they can, based on the understanding applied in this article, be located within all three oscillations (Althoff et al., 2025; Euler, 2014b; Feulner et al., 2021). DP can be understood

as a means of translating ideas, hypotheses, as well as theories and models into practical designs. As the RTD model has no intended starting point, the decision fields identified in the Decision Map can be used within all three oscillations (Reinmann et al., 2024).

However, some assumptions on which the Decision Map is based on, clearly interfere with the RTD model. By focusing on design, the RTD model creates a new structure in the relationship between design, theory, and empirical research within the DBR process. This (new) understanding of DBR emphasizes the potential for creativity and openness in design, which is especially important during the initial design of the end product or intervention (Reinmann et al., 2024). Although the Decision Map emphasises the role of early design processes, it also focuses on project-related parameters. The latter may limit the potential for innovation but may ensure practical applicability.

Another distinction between the RTD model and the Decision Map is that in the RTD model, design is the primary action. Thus, unlike the Decision Map, the RTD model does not follow a clear sequence of steps. Instead, it is understood as a model that deliberately avoids prescribing a starting point and/or a mandatory sequence of actions (Reinmann et al., 2024). Reinmann et al. (2024) emphasize that although the RTD model must be applied in a temporal dimension, the entry point and temporal sequence are determined by decisions arising from the oscillations within the three dimensions. In contrast, the Decision Map presents explicit decisions, including decision options. Thus, the RTD model remains intentionally vague, providing significant interpretive and creative freedom, particularly for advanced DBR researchers. However, for novice DBR researchers, the model's complexity (oscillating dimensions; iterative-cyclical steps within the dimensions; the cyclical structure of the model as a whole) is likely to be challenging.

The Decision Map, by aiming for structure, may somewhat constrain creative processes but provides a more straightforward entry point, particularly for DBR novices, by focusing on DP as central elements of the DBR process and offering a structured presentation of potential decisions and options in the generation of DP (Althoff et al., 2025). Nevertheless, the decisions named in the Decision Map need to be made in all DBR projects, even if no DP are formulated. In such cases, alternative ways of transparently presenting design decisions are needed (Reinmann et al., 2024). Although it is possible to use DBR cycles to collect empirical knowledge for the initial generation of DP (Keller & Siegmund, 2026a), it remains unclear if and how the Decision Map can be used to revise DP or designs.

DP play a central role in ensuring the quality of DBR projects, as they enable both transparent documentation and the transfer of results into practice (Feulner et al., 2021; Hiller et al., 2026). Building on the dimensions of the RTD model, Reinmann (2022) formulated quality standards that support this process. Within this framework, the Decision Map can contribute in particular to helping researchers present

their design decisions transparently and become aware of the potential consequences of these decisions (Reinmann, 2022). The map also plays a role in the additional meta-dimension, as it is essential here that researchers critically reflect on their own role within the DBR process, an aspect captured in the content-specific parameters.

In conclusion, it is important to acknowledge the limitations of the Decision Map. In the development, only the approaches and decisions of the three projects by the authors were considered. The Decision Map is therefore not based on a broad empirical basis but rather presents possible approaches. Due to its development based on three ongoing research projects, all situated within the field of geography education and referring to the same DBR model, the article reflects a strong alignment with the DBR understanding prevalent in the geography education research community (Feulner et al., 2021). Consequently, it remains to be explored how the Decision Map might be applied in DBR approaches beyond the context of geography education.

The various theory-practice collaborations used in the research projects indicate that the decision fields and decisions formulated in the Decision Map (Fig. 3) remain consistent regardless of the nature of collaboration. However, this article does not show how the map can be integrated into this process in a targeted manner. Adapting and applying the Decision Map to projects involving other forms of theory-practice partnerships appears both promising and desirable.

6.0 Conclusion

This article refined the Decision Map by Althoff et al. (2025) to better support the initial generation of DP in DBR. Based on a retrospective comparison of three DBR projects in geography education, the analysis highlights the importance of exploration phases, the role of theories, and context-specific parameters in the initial generation of DP. The revised Decision Map addresses these findings by incorporating them both as a framing structure and as explicit decisions within the decision fields. While the Decision Map does not constitute a comprehensive DBR model, it offers a focused heuristic, particularly valuable for researchers in the early stages of DBR projects.

Transparency statement: Generative artificial intelligence tools based on large language models were used solely for language editing and revision of the manuscript. The content, analysis, and interpretations are entirely the responsibility of the authors.

Authors Contribution: Concept, original draft: Julia Polten, Marcel Barth, Johannes Keller; manuscript review, and revision: Johannes Keller; Visualization of the decision map: Julia Polten, Johannes Keller.

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