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Pathways to educational change revisited— controversies and advances in the German teacher education system

Robin Straub [a, *], Ulli Vilsmaier [b]

[a] Leuphana University Lüneburg, Center for Teacher Education, Universitätsallee 1, 21335, Lüneburg, Germany
[b] Leuphana University Lüneburg, Institute of Philosophy and Sciences of Art and Methodology Center, Universitätsallee 1, 21335, Lüneburg, Germany

HIGHLIGHTS

- Innovation and transfer are imperative for a future-oriented teaching profession.
- Top-down approaches lack transformative momentum due to insufficient adaptability.
- Bottom-up approaches lack scientific rigor and scalability.
- Transdisciplinary collaboration fosters mutual learning and integration.
- This allows for systemic change in academic teacher education and school practice.

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ABSTRACT

This article contributes to the discourse of innovation and transfer strategies in German teacher education by (1) providing a conceptual analysis of prevalent approaches and (2) introducing a transdisciplinary perspective. The conceptual analysis indicates that top-down and bottom-up approaches lack either transformative momentum or scientific rigor. Collaborative approaches aim to mitigate this dilemma, but remain biased towards unidirectional innovation and transfer processes. In contrast, transdisciplinary approaches advocate for integrative and systemic pathways for educational change, which interlinks research and practice in teaching and teacher education. Illustrating examples from a boundary-crossing research and development project support this perspective.

1. Introduction

Educational change in teacher education refers to the capacity to initiate, establish and diffuse advancements in the educational and pedagogical field (Fullan, 2016). Moreover, educational change is linked to a wide spectrum of pathways, which are located between interventionist top-down strategies and self-reliant grassroots initiatives (Hargreaves & Shirley, 2009). Inspired by the contributions and advancements in the Anglo-American sphere (inter alia Coburn & Penuel, 2016; Snyder, Bolin, & Zumwalt, 1992; Zeichner, 2010), collaborative approaches have gained increasing momentum in the German teacher education discourse (Boer, Fahrenwald, & Spies, 2018; Kleemann, Jennek, & Vock, 2019).

However, despite the increasing acknowledgment and factual establishment of boundary-crossing approaches, a closer look reveals a much more ambivalent picture. The German teacher education system is still characterized by a three-phased and institutionally fragmented structure (Blömeke, 2006), which does not only further enhance the theory-practice gap inherent to the teaching profession (Dewey, 1904), but is also a major obstacle for innovation development and transfer (Gräsel, 2010). Thus, further advancements are needed to foster more integrative and systemic pathways to educational change.

To contribute to this vibrant discourse, the present article provides a) a systematization and conceptual analysis of the prevalent innovation and transfer approaches (namely top-down, bottom-up and collaborative), with particular consideration of the German

* Corresponding author.
E-mail addresses: robin.straub@leuphana.de (R. Straub), vilsmaier@leuphana.de (U. Vilsmaier).

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teacher education context. Based on the resulting research desiderata, the article offers b) conceptual proposals informed by the discourse of transdisciplinarity. Transdisciplinarity is an integrative mode of research and development that promotes boundary-crossing collaboration among actors with various professional, organizational and institutional backgrounds to generate academic knowledge and practical solutions (Hirsch Hadorn et al., 2008; Klein, 2014). To substantiate these conceptual considerations, illustrative examples from a boundary-crossing research and development project in Germany will be discussed.

2. Research context: trends and frictions in teacher education in Germany

The following outline focuses on the institutional structure of the German teacher education system, the overarching reform agendas and the trends in educational governance, which are understood as principal boundary conditions for educational change in teacher education.

The German teacher education system is characterized by a three-phased consecutive model comprising academic studies at universities, pre-service teacher training at teacher training colleges and schools, and advanced training during the professional career (Hericks, 2004). In addition, this model is embedded in a complex multilayered governance structure (OECD, 2003). Therefore, German teacher education is described as highly functionally specialized, but also as loosely coupled or even disciplinary and institutionally fragmented by international comparisons (Blömeke, 2006; Messner, 2012).

Around the year 2000, disillusioning results in international large-scale student assessments[1] led to comprehensive debates about the capabilities and shortcomings of the current school system and teacher education, which is commonly subsumed under the notion "PISA shock" (Raidt, 2010). During the past two decades, these ongoing debates have been a major driving force for far-reaching reform agendas enacted by the Standing Conference of the Ministers of Education and Cultural Affairs (KMK).[2] One example is the introduction of compulsory and unifying educational standards aimed at the better alignment and coherence of the teacher education system (KMK, 2014). Other reforms address the expansion and better integration of practical studies during the first phase of teacher education (Weyland, 2012), or foster coordination and cooperation among teacher educating facilities by establishing centers for teacher education and schools of education (Messner, 2012).

Moreover, the "PISA shock" has been identified as a landmark "empirical turn" in educational science and a paradigm shift in educational policy towards "output control" and "evidence-based governance" (Halbheer & Reusser, 2008). Until the late 1990s, the dominant governance policies referred to loosely coupled mechanisms of "input control" through school authorities and relatively autonomous and self-reliant school development (Altrichter, 2015). While input control refers to the specification of curricula, and thus what pupils should learn about, output control focuses on the skills and abilities that pupils should achieve (KMK, 2016). Since the enactment of educational standards by the KMK in the early 2000s, schools are formally bound to match competence-oriented requirements (KMK, 2014).

However, in addition to these reforms, a multitude of regional and local model projects involving researchers and practitioners alike have been facilitated too (Nickolaus, Abel, & Gräsel, 2006). More recently, a nationwide funding program called the "Teacher Training Quality Campaign" (Qualitätsoffensive Lehrerbildung) was launched by the Federal Ministry for Education and Research (BMBF). Over two funding phases, the program facilitates 59 teacher educating universities with 500 million euros in total. Overarching issues include, for instance, the increase of the practical orientation, the enhancement of school internships and the development of professional advisory services (BMBF, 2017).

3. Research aims and analytical procedure

Against the backdrop of a multilayered, three-phased educational system, the aim of this paper is twofold. First, this paper provides a conceptual analysis of the prevalent innovation and transfer strategies, namely the top-down, bottom-up and collaborative approaches, which allows for analyzing the given approaches and creates visibility for conceptual research desiderata. The second research aim is to provide theoretically informed suggestions for the further development of innovation and transfer strategies in teacher education by transferring the discourse on transdisciplinarity to the field of teacher education. To do so, two analytical procedures are combined within this article: (1) a conceptual analysis informed by a narrative literature review and (2) a discourse transfer and a case-based illustration.

(1) The narrative literature review followed an inductive-explorative rationale based on the authors' interpretative judgements (Bearman et al., 2012; Petticrew & Roberts, 2006). The start of the literature review comprises pertinent German-speaking special issues and edited volumes concerned with "innovation and transfer" (Nickolaus et al., 2006), "transfer and transfer research" (Gogolin & Prenzel, 2010), and "innovation within the education system" (Rürup & Bormann, 2013). In addition, a literature search was conducted using "fis-bildung", a database for German-speaking literature, which also comprises papers from the international scientific community. Subsequently, a conceptual analysis has been conducted based on an inductively developed category system. The category system comprises the following characteristics: "overall vision", "process logic", "initiation context", "innovation development", "transfer mechanism", "distribution of tasks and responsibilities", "process ownership", "goals and potentials", "quality and success criteria", "challenges and limitations", and "research methodology". Based on the conceptual analysis, further research gaps and desiderata have been outlined.

(2) These research desiderata provide structural analogies to the discourse of transdisciplinarity that has emerged in the field of education and innovation in the 1970s and that has further developed as a collaborative research mode to tackle complex problems since the 1990s (Bammer et al., 2020; Bernstein, 2015). In particular, the so called problem-solving discourse of transdisciplinarity is currently popular in the fields of sustainability, environmental sciences and health sciences, among others (Hirsch Hadorn et al., 2008; Klein, 2014). This paper seeks to (re)connect the discourse of transdisciplinarity to the field of (teacher) education and to derive theoretically informed and experienced based suggestions for a transdisciplinary approach in this field. Guiding principles for transdisciplinary research and

[1] These assessments refer to PISA (Programme for International Student Assessment), TIMSS (Trends in International Mathematics and Science Study), and PIRLS (Progress in International Reading Literacy).

[2] The Standing Conference of the Ministers of Education and Cultural Affairs is one of the most influential political committees on educational policy at the federal state level. Its German designation reads "Kultusministerkonferenz" (KMK).

development are adapted to the field of teacher education and provide conceptual advancements and the further development of innovation and transfer strategies. To substantiate these conceptual considerations, illustrative examples from a selected research and development project are presented and critically discussed.

4. Innovation and transfer strategies in teacher education

Despite the overall trend towards evidence-based governance, in Germany the output orientation is relatively moderate in comparison to Anglo-American countries (Blömeke, 2006; Gräsel, 2010). In addition, the reform agendas are far from being accomplished within academia and in the field of daily teaching practice. Against this background, ideal-typical pathways for educational change will be presented and critically discussed in this chapter.

4.1. Top-down approaches

Top-down approaches in teacher education refer mainly to development programs and strategies, which follow a multistaged and unidirectional process model. Top-down approaches are predominantly owned by researchers and/or representatives of educational administration and are designed to implement interventions either within university-based teacher education or from the outside into target schools and classroom settings. The linear multistaged process model distinguishes between two focal levels, which should not be compromised by overlaps or back references (Gräsel, Jäger, & Willke, 2005). The conceptual stage comprises the initiation and design of an innovation, whereas the application stage refers to its implementation and institutionalization within a target environment. Top-down approaches are characterized by a clear distribution of tasks, responsibilities, and roles among the involved actor groups. Innovations are developed primarily by researchers, while the representatives of the target environment, such as students and teachers, are considered part of the application fields instead of active agents of change (Rürup, 2013). Thus, in the context of top-down approaches, educational change is characterized by the relative independency of innovations' initiators from their recipients. In the context of school development, this leads to a situation where innovations are implemented from the outside into a given target system. Consequently, teachers and principals are expected to follow the preset instructions, while adaptions, modifications, and readjustments by practitioners may compromise the intended effects of the intervention.

Methodologically, top-down approaches resonate well with experimental intervention research designs, following the logic of randomized controlled trials (RCTs) (Cohen, Manion, & Morrison, 2018). RCTs are not only considered to be the methodological "gold standard" for evidence-based educational research, but also as an ideal approach for evidence-based innovation and transfer in the educational field (Gräsel, 2010; Prenzel, 2010). Due to its methodological rigor, these studies shall ensure that variations of the target characteristics are identifiable as intended effects caused by the intervention, while effects caused by other sources are kept constant. Thus, interventions that have been proven to be effective under controlled boundary conditions are considered effective in comparable settings. For strict top-down approaches, implementation fidelity counts as the primary quality criterion for the application of an intervention or innovation (Snyder et al., 1992). In contrast, moderate evidence-based approaches proclaim that factual efficacy should take priority over the ideal of implementation fidelity (Gräsel, 2010). Therefore, adjustments and adaptions to field conditions are justified when they are theoretically well founded and documented to identify possible unintended effects.

The major critique of top-down approaches addresses the alleged ignorance towards the complex dynamics of the target field and issues of limited acceptance and compliance by practitioners. The dilemma that classical interventions require laboratory conditions to be controllable implies de-contextualization from field conditions, including the school type, the composition of the student body, teaching styles and personality. Due to the heterogeneity of the educational system in Germany, it is hard to control the environmental conditions completely. Further, the high conceptual abstraction and scientific terminology of top-down approaches are obstacles in the transfer or adaption to practitioners' needs (Broekkamp & van Hout-Wolters, 2007; Gräsel et al., 2005). Educational practice, in general, is under high reform and innovation pressure, and objects to a multitude of reform agendas and innovation strategies. Therefore, practitioners often enough remain skeptical towards top-down innovation and transfer, which cannot sufficiently guarantee a good fit to pre-existing structures, processes, and working styles and account for a distinguishable benefit for teaching practice (Gräsel, 2010).

4.2. Bottom-up approaches

In contrast to top-down strategies, bottom-up approaches aim to improve everyday teaching practice through participative research and development. Bottom-up approaches emphasize the active involvement of teachers and (co)ownership of the initiation, development and implementation of innovations. Bottom-up approaches are understood as dynamic, iterative-cyclic and open-ended processes. In contrast to externally developed interventions, problem framing and the conceptualization of measures are developed primarily by or at least substantially together with the actual target group – the practicing teachers.

Rürup (2013) refers to bottom-up approaches in a rather narrow sense as grassroots initiatives that are independent of any administrative directives and public funding programs. This perspective excludes bottom-up initiatives, which take up the reform agendas induced and promoted by, e.g., federal state school authorities, the KMK, or the BMBF. In these cases, innovations are initiated and realized within the target system and owned primarily by local school representatives. While bottom-up approaches are considered to have important impacts on school development and improvement, these activities commonly do not qualify as innovation transfer since they are highly contextualized and locally bound (Gräsel et al., 2005). Nonetheless, Rürup (2013) claims that there is a vast number of local school development projects that have an impact on other schools but stay below the radar of administrative regulations and scientific observation initiatives, which resonates with what Fullan refers to as "lateral capacity-building" (2016, p. 120): the establishment of knowledge and support networks across schools to foster school development. The most prominent examples for self-reliant and highly successful projects are the award winners of the "German School Prize". This prize honors innovative school improvement endeavors to encourage further school improvement activities and to display outstanding and guiding projects that can inspire others (Beutel, Höhmann, Pant, & Schratz, 2016). Against this backdrop, it becomes apparent that Rürup's conceptualization of bottom-up approaches as grassroots initiatives tends to be too narrow. Instead, within this article, a wider understanding is suggested, which allows for the involvement of administrative and scientific actors as

long as the factual local school practitioners primarily own the change process.

In contrast to the dissemination and transfer in the context of top-down strategies, bottom-up approaches rely on diffusion mechanisms based on adaption and appropriation processes (Bormann, 2011). In this respect, practitioners actively take up, further co-develop innovations, and maintain their ownership during the innovation and distribution process. In addition, the example of the German School Prize schools indicates a rather horizontal outreach towards other schools and practitioners instead of reaching directly upwards to administration and science (Rürup, 2013). In this sense, it would be more precise to use the term "horizontal approaches" instead of bottom-up. Nonetheless, these diffusion mechanisms highlight and require the independent ability and readiness of practitioners to identify, select and incorporate external impulses with respect to the local context. Therefore, bottom-up approaches resonate well with social innovation strategies (Loogma, Tafel-Viia, & Ümarik, 2013), emphasizing the relevance of social relations and institutional embeddedness. Social innovations focus on how innovations change teaching behavior and how they affect status hierarchies or professional identities. From this point of view, the implementation of an external innovation appears as a disruptive interference with established work environments and professional self-concepts. This perspective might also explain some of the reluctance or even opposition of practitioners with respect to teacher education and school reforms.

Bottom-up strategies resonate highly with participative research and development approaches, which are commonly subsumed under the term action research. Action research emphasizes capacity building and the empowerment of local practitioners (Altrichter & Posch, 2018). Participatory action research proclaims the even further emancipation and democratization of change processes in teacher education and beyond. In alignment with that, school development should be initiated and owned within the target system, drawing on and utilizing context-specific knowledge and resources. These approaches acknowledge teachers as professional actors with situational specific competencies. Moreover, they advocate for school improvement initiatives, which draw upon local expertise and the commitment of those who are most likely to be affected to ensure in-depth and long-lasting change. Therefore, practitioners are not restricted to being mere executing agents but are encouraged to cocreate and take on responsibility for school development more extensively. Furthermore, participative approaches consider research and development activities as analytically distinguishable but practically inseparable sides of the same coin. Action research and participative research follow the iterative-cyclic research and development logics. Thus, action and reflection constitute the dualistic core of this kind of research, comprising both epistemic and transformative aims (Vilsmaier, Brandner, & Engbers, 2017).

However, bottom-up approaches mainly face critiques with regards to the lack of methodological rigor towards the assessment of cause-effect relations, an insufficient focus on more traditional scientific quality criteria and the generalizability of research findings (Altrichter & Posch, 2018). Likewise, the highly contextualized and embedded problem-solving strategies may lead to specific solutions and results, which in turn lead to certain limitations concerning the diffusion of innovation.

4.3. Cooperative approaches

The controversies on innovation, implementation and transfer strategies in teacher education peaked around 2010 and culminated in several pertinent special issues and edited volumes (Gogolin & Prenzel, 2010; Nickolaus et al., 2006; Rürup & Bormann, 2013). During that period, the debate was increasingly influenced by approaches highlighting boundary-crossing cooperation. For instance, pertinent contributions by Gräsel and Parchmann (2004) and Bormann (2011) addressed the notion of a "mutual adaption perspective'" initially introduced by Snyder et al. (1992). The term "mutual adaption" refers to approaches that acknowledge that "implementation *should* involve adjustments in needs, interests, and skills of participants and organizations as well as in project goals and methods" (Snyder et al., 1992, p. 412; emphasis in original). However, the degree to which local practitioners should have an impact on the development and implementation of innovations varies considerably.

Stark (2010) presents a research and development design that is rooted in the logic of intervention studies but highlights the importance of realistic field conditions. This evidence-based strategy seeks to develop teaching formats highly adapted to the local requirements while providing statistical findings on the effectiveness of these interventions. Others refer to design-based research, satisfying the need for scientific rigor while allowing for the necessary freedom of design (Einsiedler, 2010; Gräsel, 2010). Another proposal by Gräsel and Parchmann (2004) refers to a "symbiotic implementation strategy" that allows for the involvement of practitioners throughout the innovation and transfer process. Nonetheless, the innovation and transfer process is still primarily owned by researchers. This strategy also corresponds with the output-oriented governance approach that specifies rather broad objectives but grants high flexibility according to the implementation of the reform agenda (Gräsel et al., 2005). Others highlight the social innovation aspect of change processes and stress the importance of co-developmental or co-constructive processes among the involved parties; thus, they refer to the importance of local ownership of processes (Loogma et al., 2013).

Despite these differences, these approaches share – at least to some degree – an understanding of the co-ownership of the development, implementation, and transfer of innovations, which is reflected in the distribution of responsibilities, roles, tasks, and decision-making. The empowerment of local actors to be part of and to impact innovation is likely to increase the acceptance due to a better understanding and perceived relevance of the intended purposes and outcomes and the specific needs of the local context. This increased acceptance makes it more likely to activate local resources and commitment. Moreover, collaborative processes are more likely to follow a circular-iterative pattern, like bottom-up processes, alternating continuously between problem framing, (re)assessment, intervention, action, reflection, and adaption (Bormann, 2011). Thus, the conceptualization and application stages are intertwined.

However, due to the assumed lack of temporal resources and methodological capacities, it remains to be discussed to what extent practitioners should and could contribute to (traditional) research processes aiming to acquire empirical evidence. In this context, some authors argue that qualitative methods also provide necessary openness for practitioners' participation (Altrichter & Posch, 2018). Despite this unsolved controversy, in general, collaborative approaches set their goals rather high by claiming the capability to conduct both in-depth research-practice collaboration and methodologically sound research.

Against this backdrop, one major point of critique refers to the balancing act between top-down reform agendas and bottom-up school improvement interests. For instance, Rürup (2013) argues that cooperative research and development approaches are at risk of remaining somewhat tender forms of top-down approaches, while innovation impulses primarily resemble overall reform

agendas. From this point of view, practitioners would take on the role of researchers' accomplices or vicarious agents to reform agendas preset by educational administrations instead of truly engaging as self-independent "change agents" (Rogers, 2003). Another point of critique addresses that the general thrust of innovation still focuses on the school level and everyday practice, while practitioners' expertise has no direct impact on academic practice. In addition, the comprehensive resource intensity, which in-depth cooperative approaches require, is highlighted. The establishment of stable and functioning relations between various organizations entrusted with teacher education is not only time-consuming but also requires necessary motivational, social, and organizational prerequisites.

4.4. Contrasts and commonalities

With regard to the outline of the three ideal-typical approaches for the initiation and establishment of advances in teacher education, essential differences became apparent. These differences are summarized in Table 1.

Despite these differences and complementarities, the outlined innovation and transfer strategies tend to be conceptually biased when considering contexts where actors from different organizational and institutional backgrounds work together. Under these circumstances, each approach implies that the primary target level for innovations rests at the level of school practice. When universities, teacher education colleges and schools collaborate, innovation pressure is conceptualized predominantly within the innovation, implementation and transfer discourse as either pointing vertically down along an assumed institutional chain from academia or governmental agencies at schools or horizontally from schools to other schools. However, none of the discussed approaches explicitly questions the implied unidirectional aim.

These tacit implications become essentially problematic when the improvement of teacher education becomes the focal aim instead of teaching and school improvement. Such perspectives neglect to acknowledge more recent trends in German teacher education, as already indicated in chapter 2.

What remains conceptually underexposed is, first, that innovations at the school level often enough imply or even require innovations at the academic and governmental levels. Second and even more important, university-based innovations aspiring to be of practical relevance at the school level should also integrate sufficient expertise, experiences, and perspectives from its representatives. The increase of practical studies and the improvement of coherence among the phases in teacher education facilitate and also require bidirectional or symmetrical innovation mechanisms (Boer et al., 2018; Kleemann, Jennek, & Vock, 2019). These mechanisms indicate fruitful pathways for educational change where field practice and practitioners' expertise improve academic teaching and learning alike.

5. Bridging the gap: a transdisciplinary perspective in teacher education

Drawing on the concept of transdisciplinarity, the fifth chapter provides further conceptual considerations on how cooperative approaches could foster more integrative and thus symmetrical innovation and transfer strategies that serve both academic teacher education and school practice. These considerations will be further illustrated by examples from a research and development project in teacher education.

5.1. Theoretical background on transdisciplinarity

The discourse on transdisciplinarity has a firm stance within sustainability, environmental and health science, but it is likewise influenced by humanities and science and technology studies (Hirsch Hadorn et al., 2008; Klein, 2014; Lang et al., 2012). Transdisciplinarity represents an integrative research and development approach that acknowledges different sources of knowledge and ways of knowing across disciplinary, organizational and institutional boundaries. Transdisciplinarity resonates with what Nowotny and colleagues have introduced as Mode-2-knowledge production (Nowotny, Scott, & Gibbons, 2001). Traditional science and research (Mode-1-knowledge production) are based on traditional criteria such as objectivity, reliability, and validity. This type of research is characterized by a strict distinction between

Table 1
Ideal-typical pathways for educational change in teacher education.

Characteristics	Top-Down Approach	Cooperative Approach	Bottom-Up Approach
Overall vision	authoritative-interventional development and implementation	boundary-crossing collaboration	self-reliant school and teaching development
Process logic	unidirectional and multistaged; separation of initiation and transfer of innovation	iterative-cyclic; initiation and transfer are intertwined	interactive-cyclic; unity of invention and enactment of innovation
Initiation context	reform agendas; research projects	fit of political/research agendas and local needs	practical challenges and needs
Innovation development	development by researchers/experts	co-construction and mutual adaption	participative capacity building by practitioners
Transfer mechanism	scale-up through dissemination and transfer	transfer and diffusion through cooperative relations	diffusion of innovation through appropriation and adaption
Distribution of tasks and responsibilities	researchers are initiators, developers, and implementers of innovation; practitioners are executing agents	researchers and practitioners are co-initiators, co-developers and co-implementers of innovations	practitioners are initiators, developers, and implementers; researchers are facilitators and critical friends
Process ownership	external researchers and experts	shared among researchers and practitioners	internal agents teachers and principals
Goals and potentials	evidence-based and policy-driven teaching and school improvement	evidence-based capacity building	capacity building; oriented to the demands and needs of the target group
Quality and success criteria	implementation fidelity and evidence-based effects on target criteria	effects on target criteria; acceptance and participation of target group	acceptance and participation of target group
Challenges and limitations	risk of ill-fit with local needs; lack of acceptance and compliance in the field	resource-intensive (financial/temporal); requires high commitment	limited generalizability due to context specificity
Research methodology	mostly quantitative, (quasi-) experimental intervention designs and randomized controlled trials	broad range of methodology, including quantitative, qualitative and mixed-methods approaches	mostly qualitative research approaches; descriptive statistics

knowledge acquisition and knowledge application. In contrast, Mode-2-knowledge production takes account of both epistemic and transformative aims, e.g., the change of educational research and practice. Therefore, transdisciplinarity is characterized by an extended scope comprising not only scientific research standards but also addressing the applicability of research results, the diversity of disciplinary and professional cultures and the organizational heterogeneity in academia and practice. In addition to scientific credibility, this requires social accountability and reflectivity and an extended understanding of quality control (Lang et al., 2012). The claimed potential of transdisciplinary research and development lies within its capability of creating spaces for mutual learning and producing results that have positive effects on the legitimacy and acceptance of advances and innovations. Therefore, it is claimed that transdisciplinary processes increase the chances of transfer and diffusion by being socially and culturally robust (Nowotny, 2003; Vilsmaier et al., 2015).

Based on this theoretical background, four basic guiding principles for transdisciplinary research and development have been outlined in the context of teacher education: "problem-solving orientation", "multi-perspectivity", "participation" and "(re)integration" (Straub & Dollereder, 2019). First, a problem-solving orientation refers to the notion that collaboration should address concrete challenges deemed relevant by the involved actor groups. Second, it reflects the commitment to generate factual advancements to tackle these challenges, which again are considered suitable as such by the given actor groups. Multi-perspectivity addresses the need for various sources of knowledge across disciplines, professional backgrounds and levels of experience to address both practical and academic requirements. Participation highlights the necessity and advantages of in-depth engagements among various reference groups. Finally, (re)integration refers again to a twofold objective. First, there is the requirement for the epistemic, social and organizational integration of the relevant actor groups into cooperative processes. Second, co-constructed results and products have to be established within the reference systems such as universities, teacher education colleges and schools.

5.2. Conceptual framework of transdisciplinary processes

Fig. 1 displays an ideal-typical transdisciplinary process model (Jahn, 2008; Jahn, Bergmann, & Keil, 2012). This model distinguishes between "societal practice" and "academic practice" as two different reference systems (see columns A and C). Each system is defined by specific types of problems or challenges, involved actor groups, and discourses. It is assumed that innovative advancements necessarily refer to the specific problem perceptions within the given reference system (see rows 1 and 3). Consequentially, societal and academic practices are understood to be loosely coupled. Therefore, innovations developed in academic practice do not automatically initiate innovations in societal practice and vice versa. Transdisciplinary research and development spaces aim at fostering co-constructive interrelations between both reference systems through a three-staged process (see column B). Despite the seemingly linearity of the consecutive steps displayed in the figure, transdisciplinary engagement follows iterative-cyclic and adjusting processes. The key steps are (1B) "problem framing and team building", (2B) "integration through mutual learning and co-construction" and (3B) "re-integration and application of knowledge".

5.2.1. 1B – Problem framing and team building

In transdisciplinary processes, the initial activities of problem framing and team building are essential. They address the need to identify and construct shared problem understandings across disciplinary, professional, organizational and institutional boundaries (Lang et al., 2012; Scholz & Steiner, 2015) and intersect both challenges of everyday practice (1A) and academic research interests (1C). Since joint problem framing highly depends on the integration of different perspectives, the question regarding whether the actors are necessary, sufficiently qualified and legitimate for appropriate problem framing becomes an issue of its own (see A2 and C2; Lang et al., 2012). Moreover, the two main tasks of the first phase – problem framing and team building – are mutually dependent. Therefore, they should not be predefined a priori, but instead be explicitly dealt with as part of the transdisciplinary process (Muhar, Vilsmaier, Glanzer, & Freyer, 2006).

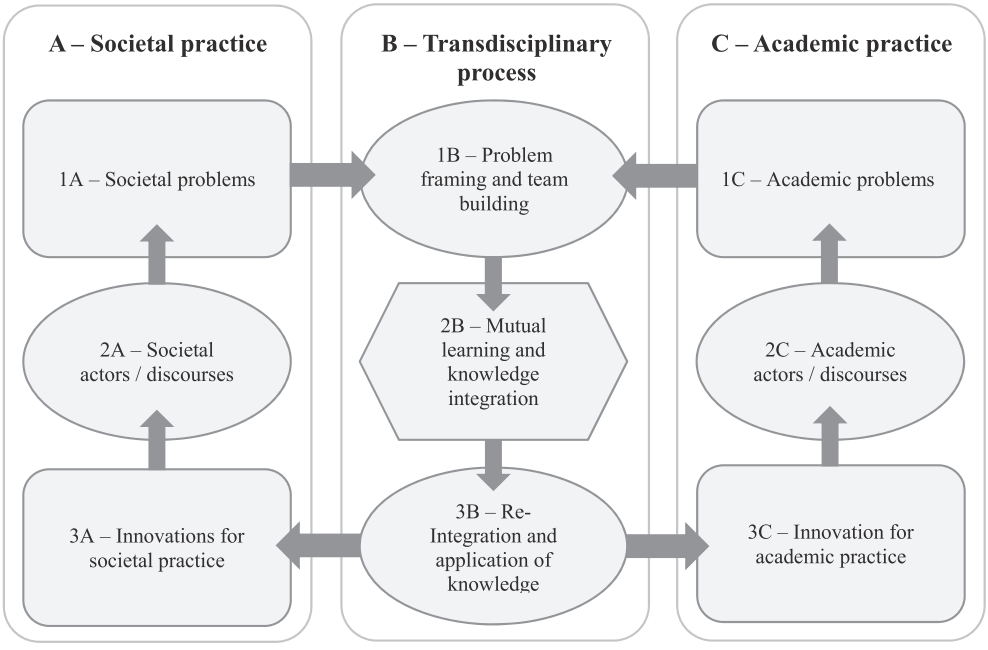

Fig. 1. Process model for transdisciplinary cooperation based on Bergmann et al. (2012) and Jahn (2008).

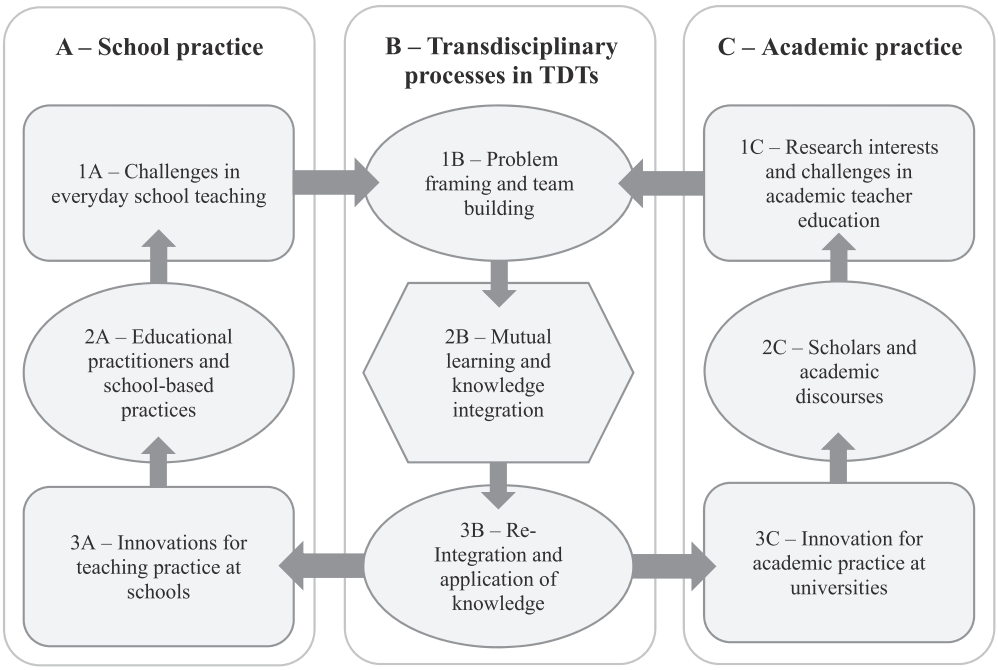

Fig. 2. Adapted process model of transdisciplinary cooperation in teacher education.

5.2.2. 2B — Mutual learning and knowledge integration

Transdisciplinary research is based on the process of mutual learning and knowledge integration (Scholz & Steiner, 2015; Vilsmaier et al., 2015). Mutual learning refers to the ability to learn *from* and *with* different actor groups through the exchange and co-construction of knowledge and experiences (Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2011). In addition, mutual learning also requires the adoption of mutual perspectives and the elaboration of a common understanding (Bayerl & Steinheider, 2009). To do so, the recognition of the differences in ways of perceiving, knowing, acting, and being becomes essential (Vilsmaier, Brandner, & Engbers, 2017). Co-constructive knowledge integration fosters a comprehensive understanding of the others' viewpoints, needs, and working methods and serves to consolidate the common ground (Bayerl & Steinheider, 2009). To develop a shared understanding of the problems and potential problem-solving approaches, collective reflection, critical feedback, and constructive conflicts are needed (Van den Bossche et al., 2011). The adoption of the others' perspectives helps to rethink viewpoints that are taken for granted within certain fields of expertise. In so doing, involved actors are more likely to generate new insights and knowledge on a more comprehensive basis.

5.2.3. 3B — Re-integration and application of knowledge

Joint problem framing and co-constructive processes ensure that various expertise and needs are taken into account to generate joint results and products that are socially (and culturally) robust (Nowotny et al., 2001; Vilsmaier et al., 2015). The reintegration and application of knowledge is directed at academia (3C) and practical fields (3A) alike, which requires balancing the scientific quality criteria and requirements for everyday practice. Again, another aim of integrative and collaborative approaches is to increase the legitimacy and ownership of co-produced results (Lang et al., 2012). Consequentially, transdisciplinary processes allow not only the interrelation of loosely coupled reference systems but also foster the reintegration and sustainable application of the co-developed concepts, products, practices and knowledge in the reference systems.

5.3. Transdisciplinary Development Teams in teacher education

The following outline of the Transdisciplinary Development Teams (TDTs) within the research and development project ZZL-Netzwerk[3] illustrates how innovations can be co-constructed and established at the boundary of university-based teacher education and school practice. To do so, the organizational structure and teamwork arrangements within the TDTs are exemplified and critically compared to the general process model of transdisciplinary cooperation (see Fig. 2).

The project's overall aim is to develop advances in teaching and teacher education through joint endeavors among representatives from universities, teacher training colleges, schools, and extramural partners. Since 2016, the representatives of these institutions established eight TDTs, which are characterized by collaboration on "equal footing" and within a "culture of togetherness". In alignment with overall reform agendas, they cover four pressing challenges in teacher education: "Competence-oriented Instruction", "Inclusive Schooling", "Mentoring in Practical Studies" and "Teachers' Health". TDTs are the main collaborative units within the network. TDTs are conceptualized as transdisciplinary research and development spaces where especially researchers and teachers and in part students, pre-service teachers, principals, teacher training educators from teacher training colleges, pedagogues from extra-curricular educational institutions, and authority representatives collaborate (Straub & Dollereder, 2019). In addition, the TDT work organization resonates with elements of (participative) action research (Altrichter & Posch, 2018) or design-based research (Bakker, 2018;

[3] The ZZL-Netzwerk is located at the Center for Teacher Education at the Leuphana University Lüneburg, Lower Saxony, Germany and is part of the Teacher Training Quality Campaign funded by the German Ministry of Education and Research (BMBF).

McKenney & Reeves, 2018). In this regard, iterative cycles of problem-framing, joint co-construction, and implementation, as well as reflection, are constitutive elements of the TDT work. In addition, action-oriented research and development was also complemented by accompanying research following more classical research approaches. These refer, for instance, to effectiveness research using pre-post designs or in-depth interview studies aiming to address explorative research questions.

5.3.1. 1B – Problem framing and team building in the TDTs

The preferably open-ended iteration between problem framing and team building was in practice prestructured by two main factors (Straub & Dollereder, 2019). First, the logic of external funding made it necessary to determine the focal aspects of the research and development program prior to the resource allocation. Therefore, primarily researchers have set the overarching topics. These topics display general debates and mandatory educational policies and reforms, while the specification of particular research and development interests are jointly elaborated in the TDTs. Second, a mixed strategy for team member acquisition becomes apparent on an overall level. First, pre-existing connections, for instance, with partner schools, have been intensified, while personal contacts helped to establish new partnerships with additional schools and other relevant organizations. This mixed strategy helped to balance different requirements such as a) the need for sufficient expertise from relevant target institutions (e. g. universities, schools, teacher training seminars, and extra-curricular educational institutes), b) meeting productivity expectations and c) maintaining stable in-depth collaboration. Thus, while keeping the overarching goals in mind (such as "Competence-oriented Instruction", "Inclusion", "Mentoring", and "Teachers' Health"), key selection criteria for team members included their relevant professional backgrounds, regional affiliations, and capabilities for long-term cooperation.

Consequentially, each team consisted of at least educational researchers and teachers representing the two focal institutions: universities and schools. In addition, depending on the specific research and development goals, further actor groups such as students, teacher training educators at teacher training colleges and representatives from educational administration and extra-curricular institutions were part of the core team (for a detailed overview of involved actor groups in each TDT, see (Straub & Dollereder, 2019: 71).

Nevertheless, the teambuilding and joint problem framing process was subject to intense negotiations and required significant time and commitment. In this regard, not only research and development goals had to be jointly specified and readjusted over time but also particular organizational processes, team members' roles and responsibilities had to be established during the process. To do so, the TDTs comprising all involved actor groups met on average every three to six weeks. Depending on the particular work organization, additional tasks, preparatory sessions, and individual meetings became necessary.

The following paragraph provides an illustrative example for co-constructive problem framing within the TDT "Teaching in Inclusive English Settings" (Straub, Spöhrer, & Meimerstorf, 2019). The team was comprised of up to 16 team members from various actor groups, such as a professor and a research assistant for English didactics, subject and special education teachers, a school principal, students, teacher training educators, preservice teachers and, occasionally, a representative from educational administration. Among others, they agreed to jointly develop and establish a university-based seminar focusing in particular on student teachers' development of attitudes, beliefs and competencies for inclusive English teaching (Blume, Gerlach, Roters, & Schmidt, 2019). In this regards a broad understanding of inclusion was established, which highlights the requirement to embrace pupils' general heterogeneous abilities and performance. In this regard, however, a debate arose concerning which aspects in particular should be focused on within the seminar. Initially, researchers and experienced teachers alike advocated general principles for inclusive teaching, which, for instance, were inspired by the universal design for learning (Blume et al., 2019). This approach was supposed to avoid that student teachers apply schematic knowledge instead of developing reflective competencies. However, student teachers, which were a part of the TDT, articulated their needs also to be able to deal with formally diagnosed special educational needs in particular. In this case, experienced teachers reconsidered their position and agreed that it is particularly challenging for novice teachers to interrelate highly abstract principles on inclusive education on the one hand and practical requirements concerning formally diagnosed special educational needs on the other hand. Consequentially, the TDT agreed to better balance holistic principles with pragmatic requirements.

Subsequently, this example of problem framing illustrates not only how this particular TDT aimed to interrelate scholarly and pragmatic requirements (theory-practice interrelation) but also how to mediate novices' needs and experts' aspirations. In addition, problem framing has to be understood as a recurring process, which is embedded in the cyclic research and development process.

5.3.2. 2B – Mutual learning and knowledge integration in TDTs

As outlined previously, mutual learning and knowledge integration are paramount features for transdisciplinary research and development processes. To facilitate both, within the eight TDTs, various forms of work organization have been established comprising different actor groups, collaborative and co-constructive processes, and dimensions of output and outcomes (Kulin, 2019; Straub & Dollereder, 2019). A central format for collaborative exchange and co-construction referred to regular TDT meetings, which again are closely coupled with the co-teaching arrangements of university-based seminars, school-based teaching or advanced training offers.

The following example of the TDT for "Competence-oriented instructional design in German didactics" is used to illustrate how the overall TDT work organization fosters mutual learning and co-constructive process and knowledge integration. In this particular example, three different collaborative formats are interrelated, namely, (1) regular TDT meetings, (2) a three-semester university-based Master's course and (3) so-called "Tandems" between students and teachers during school-based work placements (Weinhold, 2018). Moreover, the example provides insights about how the work organization promotes the interrelation between research, development and implementation activities.

The TDT consists of three major actor groups: two researchers in the field of German didactics, about eight to ten student teachers and ten established primary school teachers from regional partner schools (n_{total} = 20 to 24 TDT members). During the monthly 2-h TDT meetings (1), the team jointly addressed practice-based challenges in literacy acquisition and orthography, which were brought up by the participating teachers and student teachers. In addition to the general principles for TDT work (see chapter 4.2; Straub & Dollereder, 2019; Weinhold et al., n.d.), team-specific procedures have been established, which provide organizational structures (regular agenda items) and orientations with regard to the analytical steps for discussing content-related and didactical issues. Despite the fact that these characteristics have evolved over time, they also correspond to general findings in the research on teacher professionalization and advanced teacher training (Weinhold, 2018, p. 167).

In addition, the TDT meetings are closely related to a three-semester master's course (2). This project-oriented course comprises a five-month work placement at schools, which is framed by preparatory, accompanying, and follow-up courses at the university. During these courses, student teachers and researchers lay the theoretical foundation and engage in in-depth discussions about content knowledge and pedagogical content knowledge regarding the overarching field of literacy acquisition and orthography. In addition, student teachers carry out research projects on teaching development. This inquiry-based learning approach aims to facilitate students' professional development (Straub & Waschewski, 2019) while developing also empirical insights that are included in joint conference presentations and publications (cf. Weinhold et al., n.d.).

Moreover, during the long-term work placements, student teachers and experienced teachers form so-called "Tandems" (3). Within these, students and teachers engage in co-planning, co-teaching and co-reflection actives with regard to daily teaching practice. These tandem settings are supposed to stimulate knowledge integration through mutual learning and the co-construction of didactical arrangements. Hereby, students provide primarily theoretically and conceptually informed perspectives, while teachers contribute practical expertise and knowledge about local contexts (for instance, about pupils' performance levels or organizational processes at schools). Moreover, students and teachers take on hybrid roles by blurring the distinction between investigating and practical teaching (Weinhold et al., n.d.).

Finally, the accompanying TDT meetings (1) allow for sharing experiences and expertise among different tandems about the challenges they face during their daily practice, discussing potential solutions and jointly reflecting about eventual implementations. After finishing the three-semester course, student teachers leave the TDTs. Apart from some fluctuations, researchers and teachers continue with the next TDT cycle. In addition, regarding co-constructive development and action-based inquiry, during each cycle, accompanying research activities were conducted, using, for instance, pre-post competence tests to assess students' and pupils' performance development (Waschewski, 2018; Weinhold et al., n.d.). Complementary in-depth interviews were conducted to study developments in teacher's beliefs and self-efficacy (Waschewski, 2018).

The example of the TDT on German didactics has to be considered as fairly extensive, especially about the temporal requirements and organizational interrelations. Other TDTs, for instance, usually accompany one or two-semester seminars. In addition, the close coupling between university-based courses and classroom teaching is particularly characteristic for a TDT directly related to a teaching subject.[4] Other TDTs, such as those addressing "Teachers' Health" (Peperkorn & Frohn, 2018) and "Mentoring in Practical Studies" (Beckmann et al., 2018), focus their attention primarily at university-based seminars or advanced teacher training programs, respectively.

5.3.3. 3B – Re-integration and application of knowledge in TDTs

The previous section has already shown that TDTs do not only aim to jointly co-create, but they also aim to co-conduct and co-revise concepts, materials, and learning modules and engage in the implementation of these results. In this way, the TDT work is also concerned with the application of co-produced knowledge and its re-integration into the primary reference systems. In doing so, TDTs contribute to satisfying professional requirements and needs regarding different stakeholder groups. Students, for instance, benefit from the close interrelation of scholarly knowledge and practical expertise. These courses foster, for example, the development of attitudes, beliefs and competencies for inclusive English teaching (Blume et al., 2019), competencies in basic social and science studies with a particular focus on education for sustainable development (ESD) (Bürgener & Barth, 2018), and competence development regarding mathematical problem-solving (Schilling & Leiß, 2019).

Moreover, practitioners also benefit from their engagement within the TDTs. In addition to having access to various teaching concepts and materials (ZZL-Netzwerk, 2018), teachers are directly involved in mutual learning and co-constructive processes. Consequentially, the accompanying research findings indicate, for instance, that German teachers feel empowered to critically and reflexively implement significant changes in their teaching practices concerning learning content, materials and the learners' and teachers' perspectives (Waschewski, 2018). Another example refers to advanced teacher training modules, which foster school-based mentors' conversation and feedback competencies to support preservice teachers during their school-based work placements (Beckmann, 2019).

Finally, the boundary-crossing TDT work provided significant outcomes for university-based teacher education and educational research. In total, ten university-based courses have been established addressing pertinent facets of the overarching topics "Competence-oriented Instruction", "Inclusion", "Mentoring", and "Teachers' Health" (ZZL-Netzwerk, 2018). Moreover, within the project's context, 40 publications have been released so far, out of which 18 papers refer at least to some extent to students', pupils' or teachers' competence development, the seminar and teaching arrangements or the TDT concept and work organization. There are also examples of co-authorships among researchers, students and practitioners in publication media with scientific and practical scopes (Beckmann et al., 2018; Straub, Spöhrer, & Meimerstorf, 2019; Weinhold et al., n.d.).

Apart from generating immediate benefits for participating team members, TDTs are also concerned with the institutionalization, dissemination and transfer of outcomes into the primary reference systems. Thus, TDT work resonates with aspects of design-based research, which addresses questions of transferability (Bakker, 2018). In addition, students and practitioners are beginning to tentatively act as change agents (Rogers, 2003) who are encouraged and empowered to feed their new capacities into their school practice and spread these among their colleagues (Waschewski, 2018). With regard to the TDT on German didactics, a recent change in the team member composition was that the number of participating teachers from a partner school, which showed promising changes in teaching practices, was reduced. These teachers are alternating their participation in the TDT meetings, while teachers from another partner school are able join the next research and development cycle. In this regard, a mid- and long-term goal addresses the establishment of self-reliant working groups in the fashion of Professional Learning Communities (PLCs) (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006) or Communities of Practice (COPs) (Sim, 2006; Sutherland, Scanlon, & Sperring, 2005). However, this kind of transfer mechanism is in its early stage and requires significant support from the local school management. In addition, this strategy has to be further consolidated before other TDTs may consider adapting similar approaches.

Corresponding to the transfer of TDT outputs into the school field, further measures were taken to implement university-based seminars and teaching modules within the broader study

[4] For further examples, see Schilling and Leiß (2019) with regards to mathematics didactics at the secondary level and Bürgener and Barth (2018) regarding basic social and science studies in primary schools.

curriculum. These university-based seminars and teaching modules require intensive dialogue and negotiations with teaching colleagues, module managers and the deans' offices. In some cases, for instance, with regard to the seminar on teachers' health, the course had to be adapted to fit into the study structure and to reach a necessary consensus among cooperating lecturers. In other cases, research assistants switched to faculty positions where they inter alia work on the further development and implementation of TDT outputs at the faculty level.

In addition to that, the outlines of each seminar concept, the material collections and the advanced training modules are publicly available in German via the project's web site (ZZL-Netzwerk, 2018). At present, a video portal is under construction in which a series of video-based teaching-modules will be accessible, which is an additional channel for the distribution of teaching materials.

6. Discussion and conclusion

In the following, the results of the conceptual analysis (chapter 4) and the introduction of a transdisciplinarity approach to teacher education (chapter 5) will be critically discussed. The final section states the key conclusions and outlines some limitations and our future outlook.

6.1. Critique on prevalent pathways for educational change

The outline of current trends and frictions in educational policy and reform agendas displays an ambivalent picture. Top-down approaches resonate with competency-based educational standards, evidence-based monitoring, and output control. The advantages lie in the articulation of evidence-based intervention programs for school, teaching, and professional development (Prenzel, 2010). Such programs are usually highly specialized and focused on selective outcomes. The factual effectiveness of these programs depends considerably on their implementation fidelity and the practitioners' compliance. Moreover, top-down strategies usually do not allow for adjustments to local contextual conditions. Thus, externally driven, punctual interventions and development measures tend to lack the necessary transformative momentum to induce long-lasting change.

In contrast, bottom-up approaches foster self-reliant school improvement and regional model projects for professional development. Bottom-up approaches usually integrate target groups and allow for participation in and the coownership of processes. Practitioners' involvement is considered to be a necessary requirement for the initiation of educational change that addresses the fundamental structures and processes of a given target system. Therefore, the practitioners' commitment and support are essential for capacity building and transformation. However, they tend to be bound to socio-cultural and historical trajectories and evolutionary and small-scale innovations. Therefore, bottom-up approaches especially face limitations with respect to systematic and evidence-based change processes and diffusion.

More recently, collaborative approaches based on participative interaction across professional, institutional and organizational boundaries have gained increasing attention within the discourse on innovation and transfer in teacher education. These trends also correspond with Anglo-American developments towards more systemic and interconnected modes of educational change (Fullan, 2016; Hargreaves & Shirley, 2009). Cooperative approaches aim to balance evidence-based professional development and reflective capacity building, which is of particular importance since the loosely coupled three-staged teacher education model was never seriously called into question. Collaborative approaches promise to provide necessary integration and interconnection at organizational, curricular and personal levels to ensure effective and adaptive teacher education (Hericks, 2004).

However, throughout chapter four, it was elaborated that all three approaches are conceptually biased in terms of focusing on developing and establishing innovation and advancements at a single outcome level, mostly the school level. Against this backdrop, it has been argued that the long-term innovative capacity and effectiveness of teacher education, in general, requires a more systemic perspective, which takes the interdependencies among various institutions and actor groups into account to foster overall advancements in the multilayered teacher education system.

6.2. Reflecting the transdisciplinary approach in teacher education

Based on the previous considerations, a transdisciplinary approach was introduced. Transdisciplinarity is an integrative mode of research and development, which advocates for the interrelation of different sources of knowledge and ways of knowing across disciplinary, organizational and institutional boundaries. Moreover, transdisciplinarity offers guiding principles and integrative process logics to organize mutual learning, knowledge integration and the development of outcomes and outputs that address interrelated challenges across the three-staged teacher education system. For instance, the TDT work is characterized by "problem-solving orientation", "multi-perspectivity", "participation" and "(re-)integration" (Straub & Dollereder, 2019) and follows iterative processes of "problem framing and team building", "integration through mutual learning and co-construction" and "re-integration and application of knowledge". In this respect, transdisciplinarity resonates with and also integrates characteristics of other collaborative approaches such as Third Space (Fraefel, 2018; Zeichner, 2010), Community of Practice (Sim, 2006; Sutherland et al., 2005) and Research-Practice Partnerships (Coburn & Penuel, 2016; Penuel, Allen, Coburn, & Farrell, 2015). However, in contrast to the prevalent collaborative approach, transdisciplinarity highlights not only the integration of different actor groups within co-constructive processes but also a more symmetric benefit from generated outputs.

Moreover, as the examples from the project ZZL-Netzwerk illustrates, TDT work allows at least to some extent the blurring of traditional roles among researchers, students and teachers. In addition to university-based teaching and research, researchers engage in facilitating and co-constructing counselors for students and practicing teachers at schools. Students engage in inquiry-based learning processes, where they engage in the co-constructive preparation, conduct and reflection of teaching and in the accompanying research activities. Finally, teachers engage in co-constructive development and reflection processes within the TDT and act as mentors, designers and experts for teaching practice. In this regard, TDTs activities resemble participatory action research (Altrichter & Posch, 2018) and design-based research (Bakker, 2018).

However, the case study on TDTs also revealed some challenges and limitations. It became apparent that such boundary-crossing collaboration requires comprehensive negotiation and commitment from each involved party. Thus, TDT work has to be understood to be quite resource intensive. As illustrated in chapter 5.2, TDTs had to balance collaborative formats, which, on the one hand, foster co-constructive processes and, on the other hand, promotes cooperation, which utilized the effectiveness of the division of labor.

Moreover, the available temporal resources, especially those of participating teachers, remained considerably scarce. This is due to the fact that the initially agreed reduction of teaching hours, to compensate for the additional workload, was eventually

withdrawn by the Ministry of Education and Cultural Affairs. Consequentially, teachers received moderate monetary compensation, but had to manage an additional workload on top of their regular working hours, which is also the reason why the TDT work focused primarily on the dialogue-oriented elaboration of practice-based issues and the co-construction of potential solutions during TDT meetings, classroom observations and individual meetings with students. Eventually, TDT work would presumably benefit from the further interrelation between development and research activities, such as writing research journal papers or participating in data gathering and analysis; however, additional research and documentation requirements have not been viable, especially for the participating teachers. Therefore, primarily the participating researchers have conducted scientifically elaborate studies.

Finally, the claim for evidence-based research on the intended effects was approximated but not satisfied completely. The conditions and dynamics of TDTs hardly allow for experimental research designs. Especially, the requirements for randomization were factually not achieved. At the TDT level, these requirements would delicately violate the autonomy and self-determination of the participating actors since their foremost voluntary engagement is driven by personal interests. Similar points of critique hold true for the evaluation of the teaching concepts and materials that have been applied in unique seminar and teaching settings. Thus, the evaluations are based primarily on pretest-posttest designs. In a pointed way, Nicolescu (2008) describes this dilemma as a shift from “in vitro” to “in vivo” research.

6.3. Conclusion

Transdisciplinarity has been introduced as an integrative mode of research and development facilitating co-constructive interrelations of different bodies of knowledge, perspectives, and interests across professional, institutional and organizational boundaries. In this way, transdisciplinarity resonates strongly with recent collaborative approaches for innovation and transfer in teacher education. Moreover, transdisciplinarity provides theoretically informed principles and an iterative-cyclic process model, which support and allow for the further development of current approaches, such as Third Space, the Community of Practice, and Research-Practice Partnerships. In particular, transdisciplinarity advocates for a more integrative and systemic pathway to educational change, which is of particular importance with regard to the backdrop of the multilayered and institutionally fragmented teacher education system in Germany.

However, the foundation of the underlying conceptual analysis is rooted in a narrative literature review, which allows for a broad but necessarily abstract and potentially biased overview of the comprehensive discourse on innovation and transfer. Moreover, up to now, there are comparatively few theoretical contributions and empirical studies related to the concept of transdisciplinarity as a conceptual framework for the analysis or design of boundary-crossing collaboration in teacher education. Thus, further research efforts are needed to theoretically and empirically substantiate the conceptual considerations made in this article.

Author contribution

Robin Straub: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Ulli Vilsmaier: Conceptualization, Methodology, Writing - review & editing.

Declaration of competing interest

The authors declare no conflict of interest. All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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