

Transdisciplinary research: towards an integrative perspective

Since the emergence of transdisciplinary research, context dependencies, innovative formats and methods, societal effects, and scientific effects are key aspects that have been discussed at length. However, what is still missing is an integrative perspective on these four aspects, and the guidance on how to apply such an integrative perspective in order to realize the full transformative potential of transdisciplinary research. We provide an overview of each aspect and highlight relevant research questions that need to be answered to advance transdisciplinary research.

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The transdisciplinary research (TDR) mode involves actors from different societal domains to co-produce action-oriented knowledge, which has the potential to contribute to transformative change (Caniglia et al. 2020). The ideal-typical TDR process (figure 1, p. 244) highlights that such research is constituted in combining societal and scientific practice in a mutual learning process in which four aspects are relevant: TDR processes aim for both 1. *societal* and 2. *scientific effects* while being embedded in 3. *specific contexts*. This double-aim and embeddedness requires to develop and use 4. *innovative formats and methods* that go beyond the established disciplinary and interdisciplinary scientific repertoires to foster knowledge integration and learning processes. These four research aspects are particularly important for knowledge generation processes in TDR as they all include the complex task to integrate very diverse epistemologies from heterogeneous actors.

Context dependencies are defined by the research object and its local embeddedness (e. g., space, time). It is crucial, for example, to understand the cultural context of a research project to recognize the potential, but also the limits of transferring methods

and insights to other research projects and contexts (Nagy et al. 2020). *Innovative formats and methods*¹ in TDR are diverse due to the variety of societal problems and usage in various disciplines. Innovative formats like real-world labs have gained in popularity and therefore developed different approaches and characteristics (Wanner et al. 2018). They are used in various contexts and include different methods, for example, arts-based ones (Peukert et al. 2021). *Societal effects* are a fundamental aim of transdisciplinarity. Yet, the variety of terms, concepts, approaches, tools, and methods as well as the difficulty to attribute effects to certain research activities are still challenging for capturing and fostering societal effects. *Scientific effects* are the second fundamental aim of TDR, which are often difficult to measure. However, these must be balanced with societal effects, which are often more in focus (Newig et al. 2019).

While these aspects (except scientific effects) have often been addressed separately, there is still a lack of systematization, oper-

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¹ We deliberately distinguish between these two and provide a working definition in the section on *Innovative formats and methods* below.

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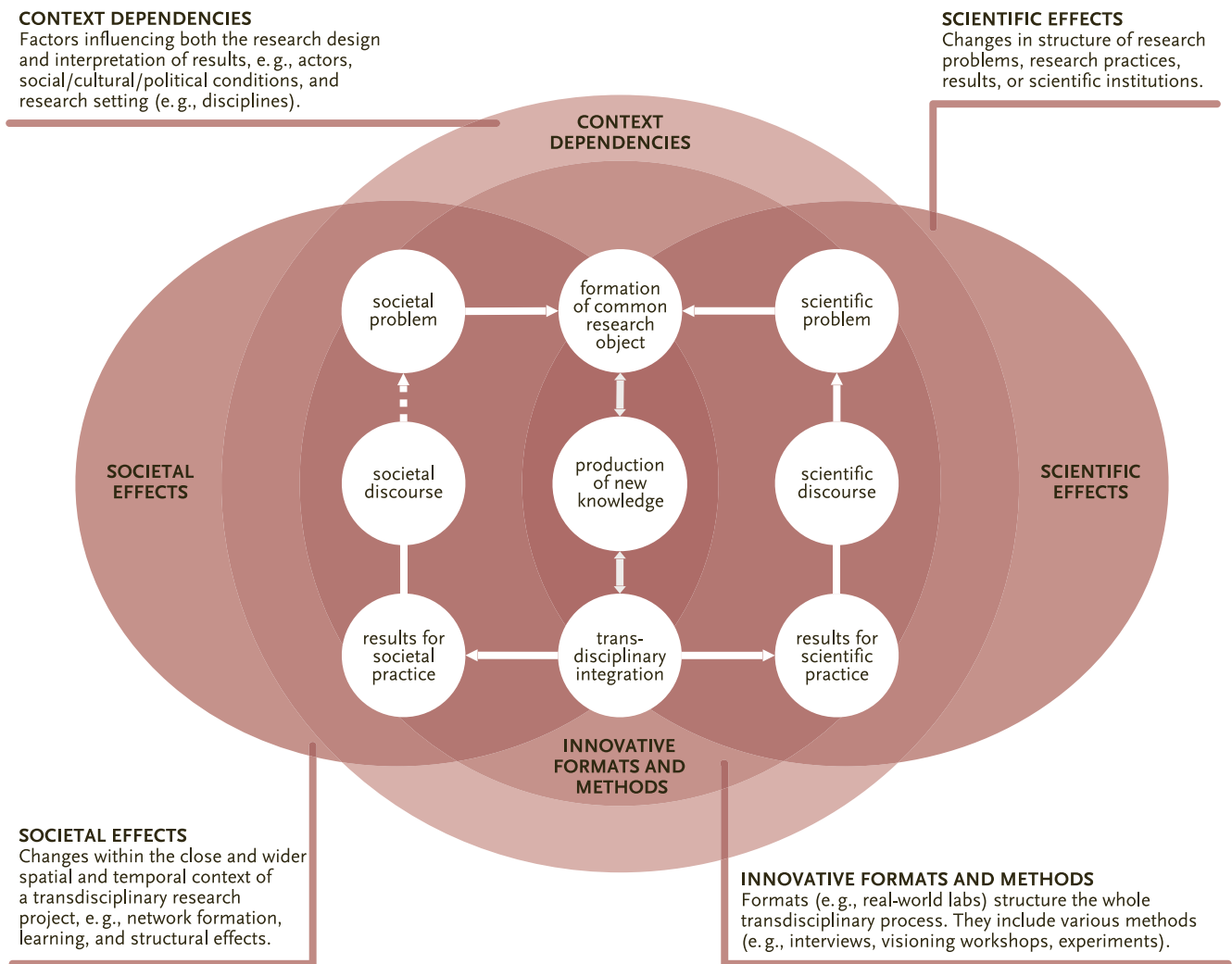


FIGURE 1: The figure shows an ideal transdisciplinary research (TDR) process consisting of the problem-framing, co-production, and (re)-integration phases (in the middle) (based on Jahn et al. 2012, Lang et al. 2012). In addition, the figure shows four aspects of TDR: context dependencies, innovative formats and methods, and societal and scientific effects.

ationalization, and understanding how to address and prepare researchers for the interconnections between these four key aspects adequately.

In this paper, we first provide a brief overview and identify key research gaps and questions for each of the four aspects that also address interconnections. Second, we reflect on three integrative approaches to advance TDR beyond them. This paper outlines the thematic foci of the *tdAcademy*, which is a platform for TDR and studies².

Context dependencies

Context dependencies have implications for the design of TDR and for the character as well as the interpretation of results and effects (Lux et al. 2019). Thereby, a twofold contextuality becomes

apparent. First, with regard to the consideration of context dependencies for realizing fruitful and effective “inner” case-specific mutual learning processes. The orientation of TDR towards societal problems and solutions highlights that both the research object and research practice are highly dependent on the specific context to which they relate. Context dependencies not only have an effect on the insights gained from certain cases, but also on the methodological shaping of research processes. The second part of this contextuality then becomes apparent in the “outer” re-integration of findings from TDR processes and its aim to provide transferable results.

Primary approaches to deal with the dilemma of initially case-related and idiographic results from research processes and their

² www.td-academy.org

transferability have already been developed (Krohn 2020, Nagy et al. 2020). A strategy in TDR is to enable learning processes between cases utilizing methods and designs that facilitate transferability or generalizability³ of case-specific findings. The need to adapt formats and methods to specific context-characteristics (e.g., Western science methods in other cultural context) is evident in all case studies even if they are located in similar context settings with comparable basic cultural assumptions. Yet, when considering the diversity of cultural contexts, the need for adaptation of ideal-typical TDR processes, design principles, and quality characteristics plays an even greater role. Especially the use of the TDR mode in the Global South and with indigenous peoples and local communities needs to be context-sensitive to avoid perpetuating power asymmetries and colonial structures (Moewaka Barnes et al. 2021). This is important as transdisciplinary research seeks to have societal effects and enable transformative change, which needs to be highly reflective and include decolonizing research perspectives (Chilisa 2017, Lam et al. 2020). Here, among others, existing power dynamics, inequalities and value conceptions must be considered.

Addressing context-specificity highlights the limits of transferability. Therefore, it is relevant to address the tension between taking the context into account to be able to develop adequate knowledge for action, and the difficulty that this context-specific knowledge is then not or only partially generalizable and transferable. This tension is closely connected with the other three aspects. Key research questions related to context dependencies to advance TDR are: how does an integrated perspective of context influence TDR processes, such as the selection of formats and methods or the emergence of societal and scientific effects? How can a systematized and integrated understanding of context dependencies (e.g., different types) contribute to transfer insights across cases and differentiate between transferable and non-transferable knowledge? How can context-specific research processes be designed to meet research and ethical principles as well as expectations of actors to foster societal and scientific effects?

Innovative formats and methods

The diversity of complex societal problems is addressed by different research areas and disciplines (e.g., sustainability science, social sciences). Both has led to a variety of applied formats and methods (Biggs et al. 2021, Defila and Di Giulio 2019), which makes it difficult to select suitable ones for each specific context. Choosing the right format is important for creating an adequate common vision for a specific topic and actor or context constellation (including the identification of a boundary object and a common research question). Also, cooperative research activities and the governance of successful integrated processes require appropriate formats (Pohl et al. 2017), which have to be developed and adapted continually, for instance, to advance their applicability.

The terms “formats” and “methods” are often used as syno-

nymy. We suggest distinguishing the terms to analyze them more rigorously and gain a better understanding of their applicability. In our working definition of formats, we define them as structuring the whole transdisciplinary process (i.e., co-design, co-production, co-evaluation) or at least two phases. Therefore, they offer a “framework” to jointly develop solutions within a transformation process referring to a specific issue. Formats of TDR fulfill minimum standards such as a joint boundary object and a collaboration between practitioners and researchers right from the project start. There might be various approaches to one format (e.g., living labs, fab labs). Formats include the usage of several specific methods in each research phase. Formats structure methods⁴, which are procedures to collect and analyze information, knowledge, and data within formats and can be adapted from various disciplines and combined differently.

“Innovative” formats have been comparatively analyzed in recent years only by Grunwald et al. (2020) who discussed four innovative formats⁵ to assess their relevance for and effects in TDR. The foci of the comparative analysis were the relatedness to a societal problem, participation of practitioners, integration of several knowledge systems and transferability. In short, the analysis gives no clear idea of the suitability of formats in specific research contexts or for certain aims. Thus, we argue for systematizing formats and methods in more detail to improve the suitable selection and effectiveness for specific contexts and purposes – either for societal or scientific effects – and make them more accessible for researchers to foster (sustainability) transformations. Hence, we focus on innovative formats which represent either a kind of second-generation format that undertook further development or is innovative in its contextual utilization. Such innovative formats are, for example, *AExpertirience* (Heinrichs and Hoernemann 2021), *Real-world labs* (Wanner et al. 2018), or *Theory of Change* (Deutsch et al. 2021). They are applied in different fields of action and diverse institutional as well as governmental contexts – respectively demanding adequate research practices and methods.

On this basis, two research questions are relevant: what are requirements of respective fields of action (e.g., energy) and aims of research regarding societal and scientific effects? How can the selection of formats and methods depending on the specific context be improved to enhance their accuracy of fit and effectiveness (e.g., societal, scientific effects)? Further research will enable systematization, which offers guidance for the selection of suitable formats and methods for TDR processes. >

3 Transferability and generalizability of case-specific findings are two distinct concepts. Please see Adler et al. (2018) for detailed discussions.

4 Examples of methods are: actor and context analysis, interviews, questionnaires or visioning workshops as well as methods for interactions between practitioners and scientists such as *Barcamp*, *Give-and-take-Matrix* or documentation methods such as *Storywall* and log books (see Bergmann et al. 2012, Defila and Di Giulio 2019; toolbox by *td-net*: https://naturwissenschaften.ch/co-producing-knowledge-explained/methods/td-net_toolbox).

5 Real-world labs, innovation groups, citizen science and “Fortschrittskolleg” (specific educational format).

Societal effects

Societal effects such as network and learning effects or change of individual or organizational practices have been extensively studied in different communities, such as sustainability, development, or public health research during the last decades (OECD 2020). Effects result from complex and non-linear processes that depend on diverse factors, such as actor constellations or situational factors (e.g., funding structures) (Kaufmann-Hayoz et al. 2016). Recent discussions have highlighted three key challenges to better grasp and achieve societal effects: understand and define, capture and assess, and reflect and strengthen societal effects of TDR.

First, understanding and defining societal effects remains difficult since researchers of different background use various terms with differing meanings. While different concepts of forms of effects with their scalar dimensions (e.g., short- vs. long-term effects, within original spatial context vs. beyond) have contributed to a more comprehensive understanding of societal effects, achieving and discussing the latter remains difficult due to the lack of a common use of terms and concepts (Lux et al. 2019, Schäfer et al. 2021).

Second, capturing and assessing societal effects is still a challenging endeavor. Researchers from different fields have developed a range of approaches, tools, and methods which seek to address the complexity of, for example, time-lags, (causal) attribution, and contextual factors of societal effects (Morton 2015). A well-developed approach is the impact pathways model that takes complexity into account and is often combined with specific heuristics of effect categories (Belcher et al. 2019). Further aspects that are discussed are the level of assessment (e.g., project or program), assessors' perspective (e.g., self-perception or external), or integration of researchers' and practitioners' perspectives in the research process (Fritz et al. 2019).

Third, the potential of reflecting on and strengthening societal effects has been increasingly discussed in recent years (Bergmann et al. 2017). Particular focus here is on the role of specific research processes and methods to foster the effectiveness of TDR (Lux et al. 2019).

Against this backdrop, we see a need to advance the reflection of societal effects in TDR processes and systematically enhance the potential of achieving them. Thus, key research questions are: how can societal effects be systematically traced in TDR processes? How can the potential of TDR to achieve societal effects be increased? A facilitated reflection of impact pathways throughout the TDR process enables research teams to learn about how to follow a targeted approach to generate societal effects throughout the whole research process. Furthermore, systematic assessment of TDR projects' societal effects is increasingly demanded by funding bodies (Allweiss et al. 2020).

While the existing literature predominantly discusses societal effects conceptually, there is still a lack of manageable tools. These tools should build on existing approaches and insights from various research communities (e.g., *Theory of Change*). They

should be easy to integrate in the work routines of TDR, lead to a continuous attention for effectiveness, and advance the understanding, assessment, and reflection of societal effects empirically. In this respect, the interconnections with the other TDR aspects in focus should be also given a closer look. For example, more research is still needed on the link of societal and scientific effects and the question to which extent they reinforce or hinder each other (Newig et al. 2019). Another relevant but insufficiently addressed interconnection is the influence of supportive or contextual factors such as power relations to achieve societal effects. Furthermore, it would be interesting to explore if different innovative formats have the potential to foster certain forms of effects.

Scientific effects

There has been little research on the scientific effects of TDR so far. The established approaches to assess the effects of research in general are quantitative indicators such as bibliometric and citation metrics, or raised funds. Yet, equating scientific effects with citations is frequently criticized even by scientists working within disciplines. For example, the decision to cite a publication often does not depend on the quality of an article but on strategic choices and power structures (Fröhlich 1999). There are ongoing discussions about how to capture scientific effects beyond citations (e.g., Kuruvilla et al. 2006).

It can be challenging, in particular for TDR, to be assessed with such quantitative indicators. For example, Newig et al. (2019) confirm the trade-off hypothesis that intensive practitioner involvement reduces the number of scientific publications and citations. However, they found that these trade-offs "can be avoided through careful project design and committed project management" (Newig et al. 2019, p. 154). Furthermore, the disciplinary orientation of many scientific journals can be a barrier for articles resulting from transdisciplinary cooperation. Also, the journals relevant to publications from TDR have often a lower impact factor. Accordingly, there are repeated considerations in the literature whether assessing the scientific effects of TDR should use alternative indicators. Since the effects of TDR results go beyond citations, these alternative indicators should also go beyond the quantitative indicators currently used (Krainer and Winiwarter 2016).

We are especially interested in effects of TDR on research practice. In the literature, for example, methodological innovations, new research questions, and changes within scientific discourse are cited as changes in research practice (Jahn et al. 2012). Literature on societal effects of TDR has described various forms of effects that affect the involved actors such as learning, network effects, capacity building or new insights into complex research fields (Wiek et al. 2014). There is empirical evidence that these effects also apply to scientists involved in the research processes (Lux et al. 2019). For example, Hegger and Dieperink (2015) empirically observed that participation in TDR contributes to

more reflexivity among researchers and a broader empirical knowledge base, while Pregernig (2007) notes an improved interdisciplinary understanding.

More research on the scientific effects of TDR could contribute to a better understanding regarding the specific value of this research mode for science. It could also provide insights into how scientific effects are linked to societal effects, context dependencies, and innovative formats and methods. For example, context dependency of TDR can promote innovative scientific results because it provides empirical data that cannot be obtained in any other way. Furthermore, insights into changes in scientific practices could potentially provide a basis for discussing possible needs for change in science in light of the complex problems of the 21st century.

tion of insights back to science in general, but also to individual scholarship and institutional settings due to, for example, the applied formats and methods, the knowledge used, and their recognition in disciplines and journals. One relevant crosscutting question to study might be to what extent research on the four aspects can lead to cross-fertilizations concerning the integration of knowledge that emerges epistemologically in very different ways.

Another relevant question to study is how the aspects cut across and might play different roles in the problem-framing, co-creation, and (re-)integration phase of TDR (figure 1). For example, it is worth studying the role of (intended) societal effects in the problem-framing phase (e.g., expected system changes in different fields of action or cultural contexts) and how they define

An integrative perspective on context dependencies, innovative formats and methods, societal effects, and scientific effects can realize the full transformative potential of the transdisciplinary research mode. We invite the research community to engage in discussions and research that provides clarity on interconnections.

Integrative approaches to advance transdisciplinary research

Working on the above-mentioned research gaps and questions with an integrative perspective can advance TDR and strengthen its contribution for transformative change. We reflect on three integrative approaches to stimulate research and debate.

Exploring and strengthening interconnections and synergies

The majority of publications on transdisciplinarity focuses on one of the aspects *context dependencies, innovative formats and methods, societal effects, and scientific effects*, which contributes valuable in-depths insights for individual aspects but risks neglecting potential synergies and trade-offs. An integrative perspective in future research can shed light on the different interconnections. Here, we illustrate some open research questions on interconnections that can advance the transformative potential of TDR. For example, we argue that studying an integrative understanding of context dependencies of research objects can inform the selection and adaptation of formats and methods. This may generate more robust knowledge that leads to societal effects and novel insights for science (Caniglia et al. 2020). We also assume that studying the interconnection between societal effects and context dependencies can provide relevant insights. Future research could study which role aims of funders, expertise of involved actors, political systems (e.g., democratic or authoritarian), or power relations play for achieving societal effects. We also regard as relevant to study how scientific effects might be determined by the context too. Studies could investigate how the co-production of context-specific knowledge affects the integra-

a targeted context-specific process. This might provide insights on who to involve from societal practice (e.g., who can promote knowledge transfer to support societal effects) and which formats and methods to use for effective collaborations. Such research requires also reflecting on available methods and their adaptation or development of new ones to accomplish scientific besides societal effects. Thus, an integrative perspective that acknowledges changing relevance of the different aspects throughout a TDR process might improve our understanding of how decisions for one aspect influence other aspects in different TDR phases (figure 1).

Further developing quality criteria as cross-cutting element

Another cross-cutting approach is the development of quality criteria with an integrating perspective on the four aspects to advance theory, methods, project designs, and capacity building for TDR. This is essential to assess potentials, evaluate progress and accomplishments, and guide funding, management, and development (Belcher et al. 2016). Research on quality criteria has a long history in TDR but remains a challenge.

Further developing quality criteria with an integrative perspective could enable that the four aspects are sufficiently considered together. Often existing quality criteria only address one aspect, such as the criteria for basic conceptual processes from Bergmann et al. (2005) which mainly deals with formats and methods to foster societal effects. Future research could develop such quality criteria that address more than one aspect. For example, future research could study quality criteria that emphasize the interconnection between methods (e.g., real-world experiment) and their suitability in and adaptability to different cultural context

for successful collaboration and to avoid perpetuating power asymmetries and colonial structures in science.

Capacity building and guidance for scientists and practitioners

Scientists and practitioners require capacity building concerning the four aspects to deal with their interconnections and respective quality criteria. TDR is conducted in more diverse and complex fields of application than ten years ago (e.g., energy, health, digitalization, social-ecological, transformative research) with innovative formats and methods being applied from different disciplines. Early-career researchers and newcomers with less transdisciplinary experiences often struggle with the complexity of the research mode, the variety of theories, frameworks, and methods, and long lists of principles of dos and don'ts to consider (Sellberg et al. 2021).

This requires the TDR community to reflect on current capacity building opportunities for less experienced and advanced scientists (as part of their lifelong learning) who seek guidance on how to deal with the four aspects including their interconnections as well as respective quality criteria and who aim for achieving transformative change (Barth et al. 2020). Such capacity building opportunities require trainings that specifically focus on the aspects, highlight and reflect on the interconnections and quality criteria, and include experiences from scientists and practitioners working in different fields of application. Such capacity building can be used to provide tentative answers to the outlined research questions on interconnections and quality criteria, and advance scientific curricula in undergraduate teaching, which works close to societal practice and addresses complex societal problems in student-led TDR projects.

In addition, similar capacity building opportunities also need to be developed, adapted, and offered to practitioners working in TDR settings. Often, the changing roles, responsibilities, tasks, and expectations are unclear for practitioners. Trainings that clarify these points, guide, and provide space for reflection can be crucial to improve participation as well as collaboration processes and contribute to achieving societal and scientific effects. Of course, such practitioners-oriented trainings have to be connected to concrete research projects in which practitioners are involved.

Conclusion

We argue that an integrative perspective on context dependencies, innovative formats and methods, societal effects, and scientific effects can realize the full transformative potential of the TDR mode. Thus, we invite the TDR community to engage in discussions and research that provides theoretical, methodological, and practical clarity on interconnections between the four aspects. We also invite to reflect on new quality criteria and capacity building opportunities that focus on the integration of the four aspects, which is relevant to further advance the TDR mode.

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