**ORIGINAL ARTICLE**

# Reasoning by analogy and the transdisciplinarian's circle: on the problem of knowledge transfer across cases in transdisciplinary research

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## Abstract

In their 2018 paper, Carolina Adler, Gertrude Hirsch Hadorn, Thomas Breu, Urs Wiesmann, and Christian Pohl propose that transferability of knowledge across cases in transdisciplinary research should be thought of in terms of arguments by analogy. We aim to advance this discussion about transferability by examining it in the light of recent ideas about knowledge transfer, extrapolation, and external validity in the philosophy of science. We problematise Adler et al.'s proposal by identifying the 'transdisciplinarian's circle', due to which even knowledge that could be of use in other projects may be identified too late for efficient knowledge transfer to take place. We then suggest that Steel's ideas on overcoming the 'extrapolator's circle' can serve as a source of inspiration for addressing the issue of the transdisciplinarian's circle.

**Keywords** Transdisciplinarity · Knowledge transfer · Analogy · Extrapolation

## Introduction

Transdisciplinary (TD) research is often seen as holding the promise of dealing more successfully with problems that have resisted traditional research approaches. By integrating knowledge from different sources, and by taking the views and interests of diverse stakeholder groups seriously, transdisciplinarity is supposed to find solutions to pressing societal and environmental problems. As transdisciplinarity is strongly solution oriented, questions about knowledge transfer are particularly important in the field: to be of use, the knowledge produced must be transferred as efficiently as possible.

The term "knowledge transfer", however, can be understood in at least two distinct ways. First, it is used as a "shorthand for a wide variety of activities linking the production of academic knowledge to the potential use of such knowledge in non-academic environments" (Davies et al. 2008). Discussions about knowledge transfer in transdisciplinarity have, for good reasons, focused largely on this kind of transfer. However, recently another form of knowledge transfer has started to gain attention in the field: knowledge transfer between cases or transdisciplinary projects. When is it possible to fruitfully transfer knowledge produced in one transdisciplinary project to another project or another case? Fully realising the promise of finding solutions to pressing problems requires the ability to answer this question. If there is no possibility of transferring learning and understanding between cases, transdisciplinary research easily appears as a problematically slow and laborious way of finding solutions to urgent problems (Adler et al. 2018; Nagy et al. 2020; Wuelser et al. 2021). In this paper, we focus on this latter type of knowledge transfer.

The recent discussion about the problem of knowledge transfer across cases in transdisciplinarity has been initiated by Carolina Adler, Gertrude Hirsch Hadorn, Thomas Breu, Urs Wiesmann, Christian Pohl, and later also Gabriela Wuelser (Adler et al. 2018; Wuelser et al. 2021). As they point out, not only is there no methodology for the transfer of co-produced knowledge across cases, but even a sufficient conceptualisation of the problem is as yet missing. In the first of the two articles in which they discuss the problem (Adler et al. 2018), they propose addressing this problem by

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conceptualising transferability in terms of the argument by analogy: to understand whether knowledge is transferable, it is necessary to understand whether the cases have relevant similarities while not having relevant dissimilarities. They see their conceptualisation as a first step that requires a follow-up in two respects. First, it is necessary to investigate how relevant aspects of cases are identifiable in practice; second, further formal analysis of the argument by analogy is required.

The aim of this paper is both to problematise and to develop Adler et al.'s (2018) suggestion. We are sympathetic to their approach and the research programme they envisage, and see their paper as worthy of this kind of direct response. At the same time, we believe that their proposal underestimates certain fundamental difficulties that characterise transdisciplinary research when it comes to identifying similarities and dissimilarities between cases. However, we also suggest that the conceptualisation of these difficulties that we offer in this paper hints at a possibility of dealing with them successfully. In the first part of this two-step argument, we draw on the work on the "extrapolator's circle" in philosophy of science (Steel 2008) and propose the notion of "transdisciplinarian's circle" to capture a fundamental difficulty for transferring transdisciplinary knowledge. As we argue, due to the way research framings are developed in transdisciplinary research, a full understanding of the central aspects of a case—and thus the ability to identify relevantly similar cases—may emerge late in the course of a research project. In other words, to learn whether knowledge gained in another case would be transferable, one has to first advance the project so far that knowledge transfer may no longer be useful. In the second part of the argument, we suggest that the philosophical work on how the challenge of the extrapolator's circle is overcome in scientific practice may serve as a loose model for identifying strategies for dealing with the transdisciplinarian's circle. We suggest this as a future question for philosophy of transdisciplinarity, and we briefly discuss some possible, more specific directions for it.

We present the argument as follows. In "Transdisciplinarity", we define transdisciplinarity and draw attention to some features of it that are crucial for understanding the issue of transferability. In "The problem of knowledge transfer across cases in transdisciplinary research" we describe the problem of knowledge transfer across cases and Adler et al.'s (2018) proposal for tackling it. We identify the potential that this approach holds for dealing with a particular type of TD knowledge transfer—transfer of knowledge from one specific case to another specific case. In "The transdisciplinarian's circle", we introduce the notion of the transdisciplinarian's circle, and explicate it in the light of relevant discussions in philosophy of science. We pay particular attention to the "extrapolator's circle" as discussed by Steel. In "Accommodations, framings, and the transdisciplinarian's

circle", we use two brief examples to further discuss the transdisciplinarian's circle. In "Dealing with the transdisciplinarian's circle", we build on Steel's work to outline some possibilities for dealing with the circle.

## Transdisciplinarity

The term "transdisciplinarity" has many partly overlapping meanings, and several other contemporary approaches, such as participatory action research and co-research, have similar aims (Whyte 1990; Schrögel and Kolleck 2019).[1] So do many theoretical conceptualisations of the interactions between science and society, such as "mode 2", "post-normal science", "triple helix", and "responsible research and innovation" (Funtowicz and Ravetz 1993; Gibbons et al. 1994; Etzkowitz and Leydesdorff 1995; Stilgoe et al. 2017; Flink and Kaldewey 2018). Let us therefore loosely characterise what we mean by transdisciplinarity in this paper.

Pohl (2011; see also Carew and Wickson 2010) has distinguished four features he takes to be central in transdisciplinarity: the search for a unity of knowledge, a focus on socially relevant issues, transcending and integrating disciplinary paradigms, and the engagement of extra-academic partners. Transdisciplinarity, therefore, is solution-oriented and often project-based research, often with a strong focus on integration, where (1) problems are framed in cross-disciplinary, non-disciplinary, or even extra-academic terms, and (2) such framing and the subsequent solving of problems happen in collaborations that include researchers from many fields, and often also extra-academic partners (Choi and Pak 2006; Hirsch Hadorn et al. 2008; Pohl 2008; Brown et al. 2010; Koskinen and Mäki 2016).

Like the other approaches and conceptualisations mentioned above, transdisciplinarity can be seen as an answer to demands that publicly funded science should focus on societally important goals, and that its societal impact should be clear (Jasanoff 2003, 2017; Maassen and Weingart 2005; Schrögel and Kolleck 2019). In addition to academic evaluation criteria, research is evaluated using "additional criteria such as efficiency or usefulness, defined in terms of the contribution the work has made to the overall solution of transdisciplinary problems" (Gibbons et al. 1994, p. 33). But despite the emphasis on societal impact, the developers of transdisciplinarity stress that transdisciplinary research is not applied research; rather, it questions the distinction between basic and applied research. While transdisciplinary projects are solution oriented and focus on societally

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[1] The terminology used to describe this kind of research is in constant flux. The terms used often depend on the diciplines involved in the project, or even on the country where the project is based.

relevant, urgent problems, such as ensuring environmental and societal sustainability in a developing area, the research conducted often includes elements that would be categorised as typical for basic research, and the projects are usually supposed to produce new knowledge (Pohl and Hirsch Hadorn 2007; Hirsch Hadorn et al. 2008; Leavy 2011; Adler et al. 2018).

Another feature of transdisciplinary projects that is noteworthy here is that they often explicitly break the customary division of labour between researchers and policymakers, according to which researchers produce the policy-relevant facts and policymakers make the decisions. This is understandable, as the result of a transdisciplinary research project is often supposed to be a solution to a policy problem—an agreement, something accepted by all stakeholders in situations that are often politically tense. In such cases, policymakers may even be represented in the research team. The political tensions can be very prominently present in all stages of research (Hirsch Hadorn et al. 2008; Messerli et al. 2008; Leavy 2011).

As we will show in the following sections, these features of transdisciplinary research make knowledge transferability across cases both desirable and difficult to conceptualise and achieve.

## The problem of knowledge transfer across cases in transdisciplinary research

Let us now describe, more in detail, the problem of knowledge transfer across cases. By contrasting the proposal made by Adler et al. (2018) with Wuelser et al. (2021) and Nagy et al. (2020), we argue that the problem can be divided in two: first, as transferability of knowledge from one case to another (from case A to case B); second, as more general transferability of knowledge from a case to something like a shared body of knowledge (from case A to the body of knowledge in TD research). We argue that the issue of transferability in the first sense requires attention and that the approach of Adler et al. (2018) is a promising way of addressing it.

As noted, Adler, Hirsch Hadorn, Breu, Wiesmann, Pohl, and later also Wuelser (Adler et al. 2018; Wuelser et al. 2021) have recently drawn attention to the transferability of knowledge across cases in transdisciplinary research. Transdisciplinary projects usually aim to come up with solutions to specific problems, so the attainment of generalisable findings, or any type of knowledge that would be relevant in other contexts, is subordinate to this main aim. Nevertheless, researchers working in such projects would naturally wish to both produce knowledge that could be used in other contexts, and to use the findings of other similar projects, whenever possible. This, however, seems difficult,

as transdisciplinarity is so strongly focused on specific cases in their entire, unique, and complex social-ecological contexts. A better understanding of the conditions under which knowledge transfer across cases is possible is needed.

As the general approach for tackling the issue, Adler and her co-authors (2018) propose thinking about transferability in terms of an argument by analogy: when two cases are sufficiently similar, it is possible to fruitfully transfer knowledge from one to the other. Following Paul Bartha's treatment of arguments by analogy, they focus on the question of the plausibility of such argumentation. Bartha (2013; Adler et al. 2018, p. 186) identifies eight criteria, or rules of thumb which can be used when evaluating the strength of an analogical argument:

(G1) The more the similarities (between two domains), the stronger is the analogy.
(G2) The more the differences, the weaker is the analogy.
(G3) The greater the extent of our ignorance about the two domains, the weaker is the analogy.
(G4) The weaker the conclusion, the more plausible is the analogy.
(G5) Analogies involving causal relations are more plausible than those not involving causal relations.
(G6) Structural analogies are stronger than those based on superficial similarities.
(G7) The relevance of the similarities and differences to the conclusion (i.e. to the hypothetical analogy) must be taken into account.
(G8) Multiple analogies supporting the same conclusion make the argument stronger.

To summarise, understanding whether two contexts are similar enough for analogical reasoning to succeed becomes one of the central tasks for addressing the problem of knowledge transfer in transdisciplinary research. This means assessing "whether the cases in question are sufficiently similar in relevant aspects while not dissimilar in additional relevant aspects" (Adler et al. 2018, p. 180) and identifying "which items in a given transdisciplinary case study count for transferability of knowledge across cases" (Adler et al. 2018, p. 187).

Adler et al. (2018) claim that the specific issue they address—knowledge *transfer* across cases—is not currently addressed in the TD literature. The topic of TD *knowledge*, however, has received attention. Adler et al. (2018, p. 181) acknowledge this by adopting what they call "the customary distinction in TD research" between systems knowledge, target knowledge, and transformation knowledge. According to Pohl and Hirsch Hadorn's succinct characterisation, these types are understood as follows: "systems knowledge as knowledge of the current status; target knowledge as knowledge about a target status; and transformation knowledge

as knowledge about how to make the transition from the current to the target status" [Pohl and Hirsch Hadorn 2008, p. 117, referring to ProClim 1997; see e.g. Hirsch Hadorn et al. (2006), Brandt et al. (2013), Karrasch et al. (2022), Lawrence et al. (2022) for the significance of the typology]. In addition, Adler et al. (2018) also distinguish between substantive and procedural knowledge. They suggest that the question of transferability may look somewhat different for different types of TD knowledge, but leave the task of examining the issue to others (Adler et al. 2018, p. 187, fn 2). Together with Wuelser, they have later done so, but instead of starting from some established typology, they analyse interviews with TD experts and identify seven types of knowledge that these experts describe as transferable: TD principles; TD approaches; systematic procedures; product formats; experiential know-how; framings; and insights, data, and information (Wuelser et al. 2021).[2]

The study of transferability of TD knowledge by type is potentially a promising approach that can build on the existing work concerning TD knowledge. However, we suggest that this approach is better suited to addressing the issue of transferability understood in the second of the two ways we mentioned at the beginning of this section: the kind of transferability that could lead to the emergence of a body of knowledge in TD research. It could help in identifying the types of knowledge that are often widely transferable, and lead to the accumulation of shared knowledge belonging to these types.

In contrast, we see the proposition Adler et al. (2018) put forward as more suitable for addressing the question of transferability of knowledge between specific transdisciplinary cases: could some knowledge from case A be successfully transferred for use in case B? Even if a shared body of TD knowledge can be identified, one may also be interested in learning from some specific case for the sake of another specific case. One's reasoning ought undoubtedly to reflect the information about the general transferability of specific kinds of TD knowledge. However, this general information can take us only that far. On the one hand, it is unlikely that any TD knowledge could be transferred to all TD cases, so even if we know that a certain type of knowledge tends to be widely transferable, we still need to ask whether a piece of knowledge of that type would be appropriate to use in a specific case (see Wuelser et al. 2021, p. 1990). On the other hand, even if we know that a certain type of knowledge tends to be poorly transferable in general, we may still hope that it

would be transferable in a particular instance where the new case is sufficiently similar to the case where that knowledge was produced.

We see as an advantage of Adler et al.'s (2018) use of an argument by analogy that it provides a method for dealing with this kind of problem. At the very least, it provides some useful heuristics—when dealing with the question of transferability between specific cases, look out for relevant similarities and dissimilarities between them. Importantly, this heuristic is applicable regardless of the typology of knowledge one uses. As long as one is interested in transferring knowledge specifically from case A to case B, reasoning by analogy can be helpful. And as we will see later, it may often be difficult to assess precisely what knowledge one could perhaps transfer from a case to another. Assessing similarities between cases could help with identifying potential candidates for knowledge that could be transferred.

More ambitiously, Adler et al. (2018) argue that the argument by analogy also offers a normative standard for transferability. What is at stake is the *appropriateness* of applying knowledge derived in one context or case to another. As they note, it is far from clear how and when knowledge derived from one case can be used in another context. Examples of actual transfers are helpful but insufficient, since it may happen that they are not appropriate in a normative sense. Knowledge transfers can, for example, be based "on mere assumptions, or on implicit but diverging use of considerations" (Adler et al. 2018, p. 183) about relevant factors. In such cases, "inconsistent practice cannot justify and provide assurance for transfer from one case to another" (Adler et al. 2018, p. 183), an explicit account of transferability is required. The argument by analogy provides such an account.

Another advantage of the approach Adler et al. (2018) suggest is that it allows for both prospective and retrospective application. This can be seen when it is compared to the approach outlined by Nagy et al. (2020). They recommend thinking about transfer as a reciprocal process. As the transdisciplinary experts involved in their study point out, "it would be very helpful if results intended for transfer were to be worked out together with representatives of potential pick-up contexts or at least be commented upon by them" (Nagy et al. 2020, p. 153). In other words, for successful transfer of knowledge from case A to case B, the teams working on the cases should ideally know about each other and cooperate.

As Nagy et al. point out, this kind of immediate cooperation is not strictly necessary; "successful transfer without exchange between originating and pick-up contexts is possible, if TD results are processed and designed in appropriate ways" (Nagy et al. 2020, p. 153). However, ensuring that such "processing" takes place is difficult in most cases. For this reason, Nagy et al. stress the importance of

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[2] For an example of a typology that distinguishes (1) generative, prescriptive and strategic knowledge; (2) critical, empowering and co-produced knowledge; and (3) emergent, tactical and situated knowledge see Caniglia et al. (2021). For an example of an analysis of different concepts of knowledge in TD literature, see Apetrei et al. (2021).

interaction and reciprocal adjustment between the project where knowledge is created and the project to which it may be transferred.

This approach appears promising for increasing transferability in future transdisciplinary projects. However, it is fundamentally future directed. Among its recommendations is identifying and working with intermediaries who can help to connect the project with other contexts, and identifying and taking into account potential future contexts of use in the course of the project itself (Nagy et al. 2020, pp. 154–155). This is not something that can be done retrospectively. This leaves the issue of transferability unaddressed for transdisciplinary projects that have already been completed (and future projects that will not be following the recommendations of Nagy et al.). In comparison, the approach by Adler et al. (2018) has an important advantage. If successful, it will potentially allow knowledge to be transferred from already completed transdisciplinary projects, since the kind of similarities required for an argument by analogy between projects A and B can in principle be identified even if project A was completed without interaction with, or even awareness of, future project B. Another practical limitation of Nagy et al.'s (2020) approach is that the number of projects to which and from which knowledge can be transferred will necessarily be limited, as one project team can only cooperate with a limited number of intermediaries and representatives of other projects. There are no such limitations when reasoning by analogy.

For this reason, we believe that it is important to continue work on the approach proposed by Adler et al. (2018). As described in the introduction, we see the identification of an unacknowledged difficulty for this approach as a necessary first step for this work to proceed. In what follows, we attempt to clarify why it can be difficult to identify, particularly in advance, what precisely will be recognised as the "items that count" for transferability in a case of transdisciplinary research—and why transdisciplinary collaborations can lead to unique understandings of such items.

## The transdisciplinarian's circle

In our view, Adler et al. (2018) leave unexamined a fundamental difficulty that arises when transferability of knowledge in transdisciplinary research is thought of in terms of an argument by analogy. We think that they fail to take into account how difficult it is to assess which features of the cases being compared are relevant for the comparison to be informative.

As noted in "Transdisciplinarity", transdisciplinary research is not applied research, as it is supposed to produce new knowledge, and various stakeholders often take part actively in the knowledge production. This means that the viewpoints of the participating stakeholders and political tensions between different stakeholder groups can influence all stages of knowledge production and shape the framing of the problem. We argue that it can therefore be difficult to predict which features of a case will end up being central in a transdisciplinary project. This can make knowledge transfer difficult even when the knowledge produced in one project could in principle be used in another: assessing whether the two cases are similar enough for knowledge transfer to be useful can only be done after we know enough about the two cases—but at that point the research has already been conducted, and there is no longer any need for knowledge transfer. We call this problem *the transdisciplinarian's circle*. In this section, we describe it in abstract terms, and in the next ones we go deeper into the problem and illustrate it with brief examples.

The name of the problem refers to the *extrapolator's circle* identified by Steel (2008). In philosophy of science, the issue of transferring knowledge across cases has been discussed especially in the literature on extrapolation and external validity, that is, the validity of applying the conclusions of a study in other contexts than that of the original study (Campbell and Stanley 1963; see also, e.g. Guala 2005; for other types of knowledge transfer in science, see Herfeld and Lisciandra 2019). Many philosophers recognise extrapolation as a form of analogical reasoning: extrapolative inferences "can be reconstructed as analogical inferences of the following kind: (1) humans have symptoms Y, (2) laboratory animals have symptoms Y, (3) in laboratory animals, the symptoms are caused by factor X, (4) the human disease is therefore also caused by X" (Guala 2005, p. 196; Guala 2010, p. 1074). Basically, extrapolative inferences are analogical inferences about causes, made in experimental research. Therefore, to be convincing, extrapolative inferences have to be convincing as analogical inferences.

As Steel (2008, 2010) emphasises, following LaFollette and Shanks (1996), a satisfactory account of extrapolation must address two central challenges: the problem of difference and the extrapolator's circle. The problem of difference arises because in virtually all cases of interesting extrapolations, there are causally relevant differences between the model and the target. How, then, can extrapolation from model to target be justified? The second challenge, the extrapolator's circle, draws attention to the "relevant similarity" between the model and the target that is necessary for an extrapolation inference to be convincing (see Bartha 2010, 2019). It seems that to ensure that the model and the target are indeed relevantly similar, one must have evidence of the relevant mechanisms in both. Having that evidence would, however, render the extrapolation redundant: "The challenge posed by the extrapolator's circle, then, is to explain how it is possible to establish the similarity of the model and target

without already knowing what one wants to extrapolate" (Steel 2010, p. 1059).

Of these two challenges the problem of difference is more closely tied to inferences about causes, and it is therefore of limited interest when we talk about the transfer of knowledge in more general terms. The crux of the extrapolator's circle, however, is relevant for us. Steel draws attention to the moment when we can know whether two cases are relevantly similar or not, which matters in all analogical reasoning. The problem of the extrapolator's circle is that to ensure that a model and a target are relevantly similar, one must know the relevant causal mechanisms in both, which renders the extrapolation redundant. We suggest that knowledge transfer in transdisciplinary research suffers from a similar problem: the transdisciplinarian's circle.

To clarify our claim, let us recall the third one of the criteria Bartha (2013) has identified: *The greater the extent of our ignorance about the two domains, the weaker the analogy.* As long as researchers do not know whether two cases are similar in a relevant manner, they cannot know what kind of knowledge transfer between the cases, if any, might be fruitful. If it is possible to ensure any relevant similarity only once the research has been mostly or entirely conducted, knowledge transfer becomes redundant.

We believe that the ambitious nature of transdisciplinarity easily leads to prolonged ignorance about the central, relevant features of any case that is being studied. Transdisciplinary research stresses the salience and legitimacy of the information produced in the context where it is to be applied (Cash et al. 2003; Nagy et al. 2020). Stakeholders "are included in the first stage of problem framing, ensuring that the questions addressed by research will be relevant, i.e. salient, and results credible, i.e. evidence appropriate for the particular policy problem" (Adler et al. 2018, p. 184). When successful, a project identifies and structures the problem in a way that all participants find convincing and legitimate. Transdisciplinary collaboration with stakeholders, therefore, increases the likelihood of arriving at unpredictable framings of a problem, so in the beginning of a project it is genuinely unclear what the framing will look like. Moreover, transdisciplinary research is characterised by iterative procedures that allow continual questioning of all initial assumptions in the project and continuing reframing of the problem at hand in collaboration with the stakeholders (Pohl and Hirsch Hadorn 2007).

The framing of the problem determines to a great extent which features of a case are central. Therefore, as long as the final framing has not been determined, it is difficult to identify the central features of a case, the ones that should be compared with the features of other cases when making assessments of relevant similarity or dissimilarity. There is thus no way of knowing whether the cases are in fact similar in any relevant sense, and it is not possible to judge

whether knowledge produced in another transdisciplinary project can be fruitfully transferred to this new context. As the final framing tends to be determined quite late in any given transdisciplinary project, it can easily be too late for knowledge transfer to be useful: most of the research has already been completed, which makes knowledge transfer from another case redundant. This is the transdisciplinarian's circle.

This has so far been very abstract. Before examining a possible way to solve the transdisciplinarian's circle, let us look more closely at some ways in which some central features of transdisciplinary research can lead to the transdisciplinarian's circle, and why thinking about transferability of knowledge in transdisciplinary research in terms of analogical reasoning is more difficult than it appears in Adler et al.'s (2018) argument.

## Accommodations, framings, and the transdisciplinarian's circle

We will now briefly illustrate the transdisciplinarian's circle by discussing two examples. One of them is a real case, the other a fictional one, though informed by real ones. Both illustrate how the transdisciplinary aspiration to create problem framings that truly accommodate the needs and interests of all relevant stakeholders can lead to unique and unpredictable framings of the central problem. Such unpredictability leads to prolonged ignorance about the central features of the case, and to difficulties in knowledge transfer.

The framing of a problem in a transdisciplinary project and the subsequent research are not dictated by the features of the local context in any automatic way. Different framings can identify different features as relevant. For some feature of the local context to play a central role in knowledge production in a TD project, it has to be identified as relevant in the final problem framing. For this to happen, a number of elements have to align successfully.

We are particularly interested in two ways in which unpredictable framings may end up being adopted in transdisciplinary research. Firstly, an unpredictable framing may be adopted because of the stakeholders' understanding of the problem at hand. A particular feature of the local context may be salient for at least some of the participants in the project; they recognise it as relevant for the issue at hand, and when the collaboration begins, it becomes one of the options on the table, so to say. Secondly, an unpredictable framing may be adopted to accommodate the different interests and values of different stakeholders participating in a project. A feature of the local context can be identified as relevant in the framing only if it successfully goes through the process of negotiations between project participants—negotiations

that may involve clashes between different interests, or unique combinations of conflicting interests.

## Framings adapted to the stakeholders' viewpoints

The explicit aim of transdisciplinary projects is typically to take into account the context-specific viewpoints of relevant stakeholders—their ways of understanding the problem at hand. This can significantly alter the ways in which the researchers in a project approach the problem. Depending on the case, the stakeholders can be companies, NGOs, or, for example, members of local communities. In a development project focusing on a slum, people living in the slum may take part in the project design, or in ecological projects in the Arctic, representatives of Indigenous communities may provide knowledge about changes over time (see e.g. Brown et al. 2010; Leavy 2011). The different ways in which the stakeholders understand the problem being studied can lead to unpredictable outcomes.

To illustrate, let us look at an example. In a series of articles and a project report, Leanne C. Cullen-Unsworth and her colleagues (Cullen-Unsworth 2010; Cullen-Unsworth et al. 2010, 2011a, b) describe a 3-year project that took place in the Wet Tropics World Heritage Area in Queensland, Australia. Its aim was to develop linked cultural and biophysical indicators of ecosystem condition needed for the protection and development of the area. The project started with the acknowledgement that Aboriginal presence in the area dates back at least 40,000 years, and traditional ways of using the land have contributed to its natural values such as biodiversity. The aim of the project was to integrate Indigenous and scientific knowledge so as to enable measuring of both ecological and social aspects of the ecosystem. The participants in the project included scientists and representatives of three traditional owner groups, as well as representatives of several national and international organisations. Active participation and collaboration with the traditional owner groups was an important part of the project; the co-researchers took part in research design, the project addressed local needs and priorities, and the results were reviewed by the participants before publication.

In the final framing of the problem, the project ended up focusing strongly on the Aboriginal perspective: "The initial problem framed was how to link Aboriginal cultural indicators to scientific biophysical indicators; however, through ongoing problem framing the linkages developed were Aboriginal cultural indicators linked to biophysical reality as perceived by Rainforest Aboriginal people" (Cullen-Unsworth et al. 2011a, p. 8). On the face of it, the geographical, biological and cultural uniqueness of the area may seem by itself sufficient to suggest that a unique framing for research will emerge. Importantly, however, such uniqueness must be salient for participants in the project in order for it to

influence the framing. Accordingly, it may be impossible to tell in advance which aspects of the local context will be identified as central in the framing of the research problem.

The Wet Tropics World Heritage Area project focused on a challenge that had been recognised in many other conservation and development projects: measuring the success of management interventions (Cullen-Unsworth et al. 2010, p. 142). The team wanted to develop indicators that could be used to inform all relevant parties of the effectiveness of the actions taken. Could it use knowledge produced in projects that had similar aims? How do we identify these projects?

The initial aim in the project was to link Aboriginal cultural indicators to scientific biophysical indicators. This initial framing of the task would make one think that relevant knowledge about the system being studied could be found, for instance, from other studies of the local ecosystem, and relevant knowledge about the processes employed for knowledge co-production could be found from other projects where scientific indicators have been linked to or integrated with Indigenous ones. However, the framing changed, focusing more strongly on the Aboriginal perspective. As a result, the apparent similarities disappear: scientific knowledge about the ecosystem gained in other studies seems less relevant, and it would make sense to look for relevant processual knowledge in projects that similarly ended up focusing on Indigenous perceptions of biophysical reality. Before the final framing was in place, this would not have been clear.

## Framings adapted to the stakeholders' conflicting interests

A transdisciplinary project may also end up with a surprising or unique framing of the problem at hand to accommodate the conflicting values and interests of all the relevant stakeholders.

As noted, transdisciplinary projects often break the accustomed division of labour between researchers and policymakers. The inherently value-laden nature of the problem at hand is recognised, and representatives of all relevant stakeholder groups are involved in the research process. The idea is to frame the problem so that all stakeholder interests and values are acknowledged. Political tensions not only enter the research process explicitly, but are supposed to do so: by acknowledging the needs and interests of all relevant parties, the project is meant to reach a solution to a complex issue.

Transdisciplinary projects focusing on the sustainable use and development of natural resources offer excellent examples of situations where the different stakeholder groups have conflicting interests. Environmental NGOs, the tourism business, and the forest industry will have differing interests in research focusing on carbon sinks or biodiversity. Communities whose livelihood is partly dependent on fishing will perceive fishing regulations from a very different viewpoint

than multinational fishing industries (see e.g. Burkhardt-Holm et al. 2008; Pohl 2008; Brown et al. 2010).

From project reports and published articles alone, it is unfortunately difficult to trace out how such conflicts have been solved during transdisciplinary projects, so we will now discuss a fictional example. Let us imagine a project that is supposed to come up with an agreement on sustainable fishing regulations in a marine area apparently suffering from overfishing. The participants of the project include officials from several countries, the representatives of international fishing companies, the representatives of local coastal communities dependent on fishing, the representatives of environmental NGOs, and scientists.

The different stakeholders have conflicting interests. Such conflicts easily translate into different preferences concerning issues such as the ways in which estimates about the size of the fish stock are produced. Accommodating the different, heavily value-laden views in an epistemically acceptable manner is not easy, and may require some ingenuity. In other words, the configuration of the interests can result in surprising mutual accommodations that lead to unique ways of framing the problem. For example, in our fictional case, the different stakeholders might not agree on any framing that would necessitate estimating the size of the fish stock. The whole question might be so strained that any attempts to find common ground regarding such estimates would be futile. So, to arrive at a solution, the project might need to do without any direct references to the size of the fish stock. For instance, the problem could end up being framed in a way that focuses on the algae on which the fish feed. Knowledge about the algae would then be used instead of knowledge about the size of the fish stock. Again, in cases like this. it may be impossible to foresee how the problem will ultimately be framed.

If one wanted to transfer knowledge produced in the fishing regulation project to another project, assessing what knowledge, if any, could be transferred would only be possible when the framing of the new project was settled enough. For instance, the fishing regulation project produced an innovative solution to the tense situation, and as a part of the solution, some interesting procedural knowledge and transformation knowledge. Could this knowledge be fruitfully transferred to another project trying to solve a similar issue in another context? Answering the question requires assessing the relevant similarity of the two cases. But this is difficult before the entirety of accommodations and framings are fairly settled in both projects. At this point, the cases can prove to be dissimilar. For instance, the participants in the new project might find a way of accommodating their interests, one that allows for estimating the size of the fish stock—surely an easier solution than the one developed in the fishing regulation case; or it might be that the team encounters the transdisciplinarian's circle: once they

realise that they might have been able to transfer knowledge from the fishing case, the transfer of knowledge is already redundant.

## Is knowledge transfer between cases impossible?

Adler et al. (2018) suggest thinking about transferability in terms of an argument by analogy: when two cases are sufficiently similar, it is possible to fruitfully transfer knowledge from one to the other. We have problematised this suggestion by introducing the transdisciplinarian's circle. As transdisciplinary research is characterised by continual questioning of all initial assumptions about the problem at hand, often together with stakeholders, the final framing of the problem necessarily becomes clear relatively late in a transdisciplinary project (Pohl and Hirsch Hadorn 2007). Two projects dealing with seemingly very similar problems may end up with dissimilar framings of the problem. Before the research has been conducted, it can therefore be very difficult to assess whether the cases are in fact sufficiently similar for fruitful knowledge transfer to happen. As Adler et al. (2018, p. 187) put it, assessing similarity implies assessing "which items in a given transdisciplinary case study count for transferability of knowledge across cases". If it is not possible to determine, early enough, which items or features of two cases are the ones that should be compared, then fruitful knowledge transfer seems very difficult if not impossible. After all, it is not very useful to retrospectively determine whether knowledge transfer might have been possible.

We argue that the transdisciplinarian's circle constitutes an important issue for transferring transdisciplinary knowledge between cases. At the same time, we believe that the very model for our notion of the transdisciplinarian's circle—the extrapolator's circle—can provide some hints for dealing with this issue (Steel 2008; see also Nagatsu et al. 2020). Before concluding, we will briefly examine this possibility.

## Dealing with the transdisciplinarian's circle

When Steel (2008) describes the extrapolator's circle, he does so in order to argue that it does not pose a universal problem for extrapolation—successful and well-justified extrapolations are possible. In this section, we describe Steel's solution and show how it can serve as a source of inspiration for developing ways of dealing with the transdisciplinarian's circle.

In his response to LaFollette and Shanks, Steel (2008) argues that extrapolators have important resources for dealing with the extrapolator's circle. In particular, they do not need to have complete knowledge of the causal mechanism in the target. Instead, the extrapolator needs to focus on

locations where one has reasons for expecting relevant differences. It may not even be necessary to compare all points where difference is expected. If an upstream difference is certain to leave its mark on some stages of the mechanism more downstream, it suffices to look at those downstream stages to detect the difference or its absence. In other words, one only needs to look for what Steel calls, following Wendy Parker, "fingerprints" or "distinctive markers" of a causal process—"A distinctive marker is a telltale indicator of a particular cause, as fingerprints are indicators of the manual contact of a particular person" (Steel 2010, pp. 1065–1066).

Thus, the extrapolator may successfully extrapolate on the basis of relatively limited knowledge about the target system—more limited than the knowledge one ultimately achieves via extrapolation. There is then no circle. The problem of the extrapolator's circle may still sometimes arise where the relevant (limited) knowledge is absent, but this does not occur in every case of extrapolation.

It is important to note that Steel's solution is not directly suitable for dealing with the transdisciplinarian's circle. He talks about situations where knowledge about causal mechanisms is central. Scientists know that in case A, there is a certain causal mechanism at work and they know that it leaves distinctive "fingerprints". They want to know whether knowledge about A can be extrapolated to case B and for that they need to know whether the same process is involved in B. To establish that, they look for the "fingerprints" in B—if there are none, B is different from A.

In other words, in the extrapolator's circle the causal mechanisms are out there—the problem is our ignorance of them. The transdisciplinarian's circle is different. It arises because framings in TD research are unpredictable and slow to take shape. They are not something out there to be uncovered; they are co-created in the course of TD research. Nevertheless, we suggest that Steel's argument offers a useful insight—we do not need to compare case A in its entirety to case B in its entirety. Instead we can make partial, step-by-step comparisons. We suggest that when dealing with the prolonged and unpredictable process of framing in TD research, such comparisons may need to be made repeatedly, and more than one case may be needed for comparison. Reasoning by analogy in knowledge transfer between TD cases needs to be dynamic and iterative.

As an example, at the beginning of case A, one may assume that it is similar to case B with respect to some specific kind of knowledge one is interested in transferring. One can then start working under the assumption that this knowledge is transferable, based on the reasoning by analogy. However, as the case unfolds and the framing is negotiated and takes shape, a new comparison is in order, and it may show that case A has significantly diverged from case B. Looking for transferable knowledge may now require turning to case C. Such partial comparisons may be needed

repeatedly throughout the process of working on case A. Here, work on different types of knowledge in TD research may be helpful—different types may be relevant at different stages of a project. Some types of knowledge may be usable even if discovered as transferable relatively late during a project.

To flesh out this abstract scheme, let us return to our sample cases. Someone starting work in a project that attempts to develop ecosystem state indicators in an area where Indigenous people have lived for millennia may conclude that their case is very similar to our example case from the Wet Tropics World Heritage Area. If they are interested in transferring from it some knowledge that is suitable for the beginning stage of the new project, according to an argument by analogy they are justified in doing so. However, as the project unfolds, they will need to repeatedly revisit this judgement of similarity. For example, it is not a given that in the ongoing case the indicators will end up being tied so tightly to the perceptions of the Indigenous people involved. If not, this would constitute an important divergence from the Wet Tropics case, and new candidates for relevantly similar cases would be needed.

The fishing regulation case would most likely not be the first candidate anyone would choose for knowledge transfer. We introduced the case as an example of a highly idiosyncratic framing that emerged after everything else failed. Someone starting a new project in a similar setting may reasonably hope that a more straightforward approach will work. A relevant case for the initial comparison would therefore be one where a less roundabout approach did in fact work. Only if the ongoing case would prove to be particularly fraught, would learning from our fishing regulation case become relevant.

The solution to the transdisciplinarian's circle that we have just suggested is as yet very schematic. There are two ways in which it could be developed further.

First, we agree with Adler et al. (2018) that more work is needed on how to compare cases and recognise similarities and dissimilarities. Here, we have shown that such comparisons must be performed repeatedly through the course of a project.

Secondly, and very tentatively, we suggest exploring whether some characteristics of a transdisciplinary case could allow for forming reasonable expectations about its likely development with regard to framings. For example, it may be possible to identify some telltale signs at the beginning of a project that would indicate that a highly idiosyncratic accommodating framing is likely to be needed. This would be helpful when attempting to identify potentially similar cases. It is important to stress that identifying such possibilities, though inspired by Steel (2008), is far from the objectivity of causal mechanisms and their "fingerprints". Continuing the crime investigation metaphor, we envisage

something similar to the method of Agatha Christie's Miss Marple. Miss Marple can often suggest insights into human motives and behaviour and offer predictions, because she is able to relate new cases to previous ones she has already observed in her home village. In the case of TD research, the ability to relate a new case to an old case, or cases, would in particular mean the ability to forecast how the process of framing is likely to unfold in the new case. If such predictions are possible in TD research, they would sometimes allow for bypassing the transdisciplinarian's circle. For reasons we have already discussed at length, we doubt that this would be possible very often. Nevertheless, exploring the possibility seems worthwhile.

## Conclusion

Adler and her co-authors (2018) seek a general approach for tackling the issue of the transferability of knowledge across cases in transdisciplinary research. They suggest thinking about transferability in terms of an argument by analogy: when two cases are sufficiently similar, it is possible to fruitfully transfer knowledge from one to the other. As they point out, determining which features of the original context are critical to the analogical inference is crucial in all analogical reasoning (Bartha 2010, 2019).

We agree that arguments by analogy are important when discussing knowledge transfer across cases. However, it seems difficult to identify the relevant aspects of two transdisciplinary cases—the ones that should be compared—before the entirety of accommodations and framings are in place in both projects. Because of the ambitious nature of transdisciplinary research, this tends to happen quite late in transdisciplinary projects. Therefore, by that point it may easily be too late to benefit from knowledge transfer. We called this the transdisciplinarian's circle.

It is important to stress that we describe the issues that may arise with research framing as mere possibilities; further empirical research is needed to see how common they are in practice. Nevertheless, given their close connection to some of the central—and desirable—features of transdisciplinary research, such as the continual questioning of all initial assumptions, and the central role that is given to stakeholder viewpoints, we believe that identifying these issues and the transdisciplinarian's circle can help with attempts to understand better why knowledge transfer between cases seems so difficult in transdisciplinary research.

We also argued that turning to our source of inspiration for the transdisciplinarian's circle—Steel's (2008, 2010) work on the extrapolator's circle—may indicate a direction for dealing with the transdisciplinarian's circle in practice. In particular, thinking in terms of partial comparisons is a

useful insight. In the case of TD research, this would mean looking for similar cases and making comparisons repeatedly throughout a project.

Finally, it is important to stress that we do not see our argument as invalidating Adler et al.'s (2018) proposal. However, we believe that it complicates the picture, and that further research on transferability and analogical reasoning needs to take this into account.

**Data availability** This is a philosophical article. No data was collected or used.

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