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Conceptualizing transdisciplinarity: How do visuals mean?

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ABSTRACT

Transdisciplinary research is commonly understood as a research collaboration between different academic disciplines and actors from different sectors of society to co-produce knowledge needed in addressing real-world problems. In this paper, we understand transdisciplinary research as *an epistemological object* and study how researchers conceptualize it through visualization. To do this, we analyzed a set of related visuals in their textual context published over the last 20 years. This multi-modal analysis shows that transdisciplinarity in our set has, throughout the years, consisted of three main categories: science, practice, and the transdisciplinary research process. Transdisciplinary research has been visualized as a stable double-joint cyclical narrative starting in the settings of science and practice, after which actors join to collaborate, both depart with the results of collaboration. An assumed principle is continuously and implicitly visualized: the idea and ideal that science and practice are contributing, collaborating, and reaping benefits on the basis of equality. Supported by the literature, we problematize this way visuals obscure imbalances in practice. Finally, we discuss how visuals mean and what other ways of conceptualizing an epistemic object like transdisciplinary are possible.

1. Introduction

A shared assumption in the literature on grand environmental challenges is that they require transdisciplinary research.¹ Transdisciplinary research is commonly understood as a research collaboration between researchers and actors from different societal sectors, transcending disciplinary boundaries and integrating thought styles to co-produce knowledge needed in addressing real-world problems (Lang et al., 2012; Jahn et al., 2012). The idea is that through such collaboration pathways for change can be developed (Hoffmann et al., 2019; Klenk and Meehan, 2017). Working transdisciplinary shapes all phases of the research process and thus has important implications for how research is planned, organized and executed (Hoffmann et al., 2019). Overtime, transdisciplinary research has increasingly been carried by sets of principles and perceived best practices (e.g., Pohl et al., 2017). It has become an institutionalized approach to doing research, a shared practice in research institutes and networks, and a requirement in policy and funding programs.

This paper starts with a broad interest in how transdisciplinarity is conceptualized, which we define as giving meaning, in multiple ways

and over time. We aim to contribute to a better understanding of how transdisciplinarity has been given different and similar conceptual meanings. To do so, we look at transdisciplinarity as *an epistemic object* (Knorr Cetina, 2001). This concerns “scientific objects of investigation that are at the center of a research process” (Knorr Cetina, 2001: 181). An epistemic object is not singular and stable; it is multiple and emergent (see also Foucault, 1972: 31–39). Seeing transdisciplinarity as an epistemic object acknowledges it is complex. It also suggests that transdisciplinarity is not a definite thing but consists of process and projection. Even if one might think that research will reduce its complexity, it might also reveal it and generate as many questions as it answers (Knorr Cetina, 1997; 2001). Think, for example, of the scholarly dialogue on the risk of instrumental use of transdisciplinarity and issues of power surrounding it (e.g., see Harris and Lyon, 2013; Fritz and Meinherz, 2020; McKee et al., 2015; Lux et al., 2019; Horcea-Milcu et al., 2022; Turnhout et al., 2020; Lawrence, 2023).

We analyze representations of transdisciplinary research that endeavor to capture its core in a condensed form and help to enact it (Law and Urry, 2004): our focus is a particular set of related visuals in research publications published over the last 20 years. We draw

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¹ For readability, throughout the paper we talk use the concept transdisciplinary research and transdisciplinarity interchangeably. The paper is about transdisciplinary research, not about other forms of transdisciplinarity.

inspiration from the socio-semiotic approach to visuals (Kress and van Leeuwen, 2021; Rose, 2023) and interpretive policy analysis (van Hulst et al., 2025; Yanow, 1996, 2000). This approach allows us to investigate the way through which visuals categorize the elements of transdisciplinary research (what it is) and narrate their relationships through time (how it works). It also makes us sensitive to the ideology that might infuse the visuals. On this basis, we studied a set of related visuals published in our field since 2005.

Visuals can be significant in that they denote implicit and explicit knowledge and understanding about an object held by a community (Kress and van Leeuwen, 2021). Visualizing involves the selection of aspects, including design elements, color and choices of form to present a clear message (van Beek et al., 2020). We live in an increasingly visual world, so it matters how visuals represent and help constitute social realities (Kress and van Leeuwen, 2021). Regarding visuals in research, Pradies et al. (2023: 1250) suggested that they “may be the strongest messages we send to our audience.” Although visuals have become more central to the communication and reproduction of ideas in environmental science and policy (van Beek et al., 2020; Metz and Rojas-Padilla, 2024), researchers have not paid enough attention to the work they do (Metz, 2020). The issue is not that visuals simplify; all scholarly representations do. The question is *how* they do it (Yanow, 1996: ix-xiii). Examining in detail how this takes place allows us to evaluate its consequences and how we might compensate for the drawbacks. Our research question thus is: *How does transdisciplinarity mean through visuals?* We study this by a multi-modal analysis of a set of visuals and text in well-sited and influential academic papers on transdisciplinarity.

The results of our analysis indicate, first, that in the set of visuals we studied the elements of transdisciplinarity have been visually categorized through three black boxed main categories: science, practice and a transdisciplinary research process. Over time, the transdisciplinary process became the focus of the visuals, while the found visuals diminished in informational content. Second, we identify a double-joint cyclical narrative in all visuals. The narrative of transdisciplinary research starts in the settings of science and practice, after which scientists and practitioners join to collaborate, then depart with the results of the collaboration, after which a new episode of the narrative can start. Third, our results reveal an implicitly assumed principle in transdisciplinary research: the idea and ideal that science and practice are contributing, collaborating and reaping benefits equally and based on equality. This conceals possible power differences between disciplines, between professionals, citizens, and between science and practice. In the last part of the paper, we discuss alternative ways to conceptualize transdisciplinarity in visual modes. As, for instance, a recent *Handbook of Transdisciplinarity* shows (Lawrence, 2023), transdisciplinarity can be conceptualized and visualized in many different ways. To enrich and thicken our descriptions of transdisciplinarity, we might therefore look at alternative (e.g., Klenk, 2018) and complementary visualizations (e.g., Pohl et al., 2017).

2. Conceptualizing and visualizing transdisciplinarity

Transdisciplinary Research in the Environmental Sciences has been proposed as a promising approach that enables the integration of different types of knowledges; from different disciplines as well as experiential and local knowledge and values in order to address environmental problems (Klenk, 2018; Lawrence, 2023). Following Knorr Cetina (1997; 2001), in this paper we consider transdisciplinary research as an epistemic object. Naming an epistemological object, in our case through the concept of transdisciplinarity, is “a way to punctuate the flux, to bracket and ignore differences, to declare them as pointing to an identity-for-a-particular-purpose” (Knorr Cetina, 2001: 184), allowing for the translation across (institutional, national, etc.) boundaries and to bring it “into accordance with project-financing requirements, work organization principles, institutional career tracks,

and so on” (Knorr Cetina, 2001: 184). Yet as an epistemic object, transdisciplinarity unfolds indefinitely. This resembles Knorr Cetina (2001: 181) suggestion of an open drawer filled with folders extending without end into the depth of a dark closet. An epistemic object constantly acquires new properties and changes the ones it has. It is constantly mutating into something other than what it was at one point in time. This also means that it is always lacking and “never quite [itself]” (Knorr Cetina, 1997: 13). Furthermore, an epistemic object is dispersed through its many instantiations, which might range from representational to material. Even if a particular instantiation of it might be finished, those who research it hold it up against an ideal, imagined object, that “might itself be instantiated in design drawings that project a future or hidden state” (Knorr Cetina, 2001: 183). Research will never catch up with the object it is intended to represent. It encounters lacking elements and points at further epistemic work that is needed to understand it better. Finally, in the process, interests in particular dimensions of the object might shift, and research might continue in a somewhat different direction (Knorr Cetina, 2001).

Visuals of transdisciplinarity, as instantiations of the epistemic object, do conceptual work for those who make and consume them. Kress and Van Leeuwen (2021; Höllerer et al., 2018) explain how conceptual visuals depict categories and how they narrate events taking place in them. Categorization involves assigning a meaning to what is depicted and establishing its elements (Yanow, 2000). It works to answer the question of what the object visualized is, what parts (categories and sub-categories) it is made of, and how these parts relate to each other in space. To understand how the work of visuals, we, therefore, must carefully study their composition features (Kress and van Leeuwen, 2021; Rose, 2023). There are typical features of visuals: categories, for instance, are typically placed in boxes. We can analyze how the parts of the object visualized are related and how they work together in time. We also can study how visualizations narrate, which involves descriptions of events and entities placed in settings, typically with a beginning, middle and end (van Hulst et al., 2025). Arrows in them depict the moving through time. Finally, interpretive thinking suggests that a visual might be both a descriptive model of reality and a normative model for reality (Geertz, 1973), making a leap from *what is* to *what ought* to be the case (Rein and Schön, 1977). A visual can be studied for signaling a certain ideology. With its composition and symbols included in it, it might explicitly or implicitly, offer judgement of what is desirable and what is not (Rodriguez and Dimitrova, 2011; Rose, 2023).

Next to the conceptual work visuals do, a visual, as a condensed version of an object it represents, can become a relatively stable reference point for various actors working on or with the epistemic object. It can be moved around easily while keeping its main features (Latour, 1986). It may become an object that is both plastic enough to be interpreted differently across different settings, but at the same time carry enough common meaning to enable collaboration across practices (Star and Griesemer, 1989). Alternatively, the meanings made through a visual might shift overtime (Law and Mol, 2001; Mahony, 2015). Although there are many kinds of visuals, a visual is a certain mode of representing that differs from the best-known alternative in the context of research publications: extended verbal text. If we compare them as ways to understand an epistemological object, a visual is apprehended in a more spatial, immediate and holistic manner, while a verbal text is understood rather in linear, sequential and additive fashion (Meyer et al., 2013: 494–5). In publications, visuals are embedded and put side-to-side with verbal text. Publications are *multimodal*, and the relationship between the two modes needs to be taken into account (Kress and van Leeuwen, 2021; Höllerer et al., 2018). Finally, publications with the visuals are embedded in the literature on a topic. We should expect a “travelling of visuals” (Rojas-Padilla et al., 2022) through the network of publications and transdisciplinary research practices. Therefore, we should try and understand the relations between visuals and the embedding in the literature over time.

3. Methodology and methods

The starting point of our project was Hoffmann et al.'s (2019) visual of transdisciplinary research. Encountering this conceptual model (Langley and Ravasi, 2019), made us curious about its meaning-making work. Using Rose's (2023): 105–114 suggestions for identifying visuals for visual analysis, we embarked on a visual case study. We soon realized that the visual was very similar to the ones in Lang et al. (2012) and Jahn et al. (2012), two very well referenced papers on transdisciplinarity. Our case study is not the study of all visuals of transdisciplinarity, but a much more limited, yet meaningful endeavor: the study of a particular visualization of transdisciplinarity. It consisted of seven activities: 1. Tracing through references; 2. Searching through images recognition; 3. Determining the set; 4. Studying each individual visual carefully; 5. Comparing visuals with verbal text; 6. Comparing visuals with each other; 7. Writing up.

First, starting from Hoffman et al. (2019) we traced backwards and forwards in time through the references in the articles that contain a version of the visual. Versions of the visuals we selected were those with significant similarities, for example in entities and form (Kress and van Leeuwen, 2021). This helped us develop a set of visuals, with Jahn (2005) as the earliest in the set. Second, to make sure we did not miss versions of the visual and to find newer ones we also did Google Image searches (2–1–2025; 7–1–2025) on “transdisciplinarity Hoffmann” “transdisciplinarity integration”, “Transdisciplinary research projects with science and practice”, “Transdisciplinary research process”, “framework Transdisciplinary research process”, “conceptual model Transdisciplinary research process”. Since Jahn (2005) was the first one we found, we also searched “transdisciplinarity Jahn” to ensure the sample captured early as well as later visuals.

Third, to complete the set for our visual analysis, we limited the study to research publications, selecting those publications that made alterations to the Jahn's (2005) starting point (not exact copies). The set of publications we selected for our visual analysis consisted of those that entailed some alteration to its main elements. This also meant elements were kept the same for it to be a variation of the same visual. This brought us to a set of 13 visuals we analyzed in 11 publications (two publications offer two visuals - Jahn, 2005 and Bergmann and Jahn, 2008). Together, the dataset of visuals covers a period of twenty years.

Fourth, our analysis consisted of looking at the *studying the aspects of each visual*: a. the categories that make up the visual and how they relate (composition: position, size, color and verbal labels, including the titles given to the visuals) – what things are; b. the narrative elements (boxes as, for example, actors or other entities; arrows as activities or developments) and overall narrative suggested in it (beginning, middle, end) – how things work; c. the normative, ideological signification that might come with a and b – how things should be/work. Fifth, we also *read the texts and compare these to the visuals* to understand better the multimodal (Kress and van Leeuwen, 2021) work being done. That is to say, the verbal and the visual, two different modes of communication, work together. The publications in our set as such are different. They range from more empirical to more theoretical. There are various connections to sustainability or a more specific theme. One, for instance, was an evaluation of a project with municipalities (Brink et al., 2018) and another was meant as a practical guide (Pohl et al., 2017). Sixth, we *compared visuals through time*. What is similar, what has been altered and how? We went through these steps in an immersive and iterative fashion (Kress and van Leeuwen, 2021; Rose, 2023), zooming in on individual visuals and out to the broader set and the embedding publications. We made elaborate notes on relevant aspects in a shared Excel file. The first two authors did the visual analysis and the third infused the process with critical questions and stimulated further analysis and reflection. Studying the visuals in this detailed, comparative manner, it became clear to us that many elements have changed (arrows, boxes, background, concepts), but at least the overall idea (science and practice as equal partners) has survived. In the three analytical steps, we

encountered similarities and differences between the visuals. Finally, after going through these steps, we wrote up our empirical analysis.

As we trace the materials, focusing on the visuals, we follow an epistemic object through time. The travelling of visualization through the network of publications can be read as an intertextual dialogue (Rojas-Padilla et al., 2022). The study is not a study of the various possible ways of visualizing transdisciplinarity, but a case study of a particular set of visuals. While we think visualization has important merits for theory and practice – e.g., abstracting important elements of a phenomenon (Knorr Cetina, 2001), our analysis is critical of the way these visuals mean. To expand the dialogue towards the epistemic object visualized, we use the discussion part of the paper to point at various alternative and complementary visualizations.

4. Findings

The results are structured according to key themes of categorization, narration and idealization. Each is discussed separately in what follows (4.1, 4.2, 4.3). Text boxes 1 and 2 offer more detail on categorization and narration, respectively, to give the reader a better sense of the empirical material of articles that are less discussed in the main text.

4.1. Categorization: two sides and the stable focus in the middle

The first thing that stands out in the visuals is how transdisciplinarity is presented as consisting of two sides and a middle. Jahn (2005), see Fig. 1, the first publication in the set, somewhat implicitly visualizes science and practice as entities on two sides. What happens on the two sides is similar. Heterogeneous discourses are turned into problems that are offered to a middle where both come together in a joint investigation (see also, Jahn et al., 2012, see Fig. 2). In various of the later visuals, science and practice are presented more explicitly as distinctive categories, which is signified through boxes (e.g., Lang et al., 2012; Cockburn et al., 2016, see Fig. 3). Each of the three main categories also gets its own label: societal practice, scientific practice and transdisciplinary research process. Later they are categorized as “realms” by Pohl et al. (2017) and “spheres” by Hoffmann et al. (2019), see Fig. 4. In later visuals, the distinctions are/is reinforced with each side getting their own question (“does it work? is it true?”).² In the figures, from both sides, “contributions” are made to the middle, demonstrated through arrows which point towards the middle of the visual, where the transdisciplinary research process is found. In almost all figures (exception Pohl et al., 2017), the three main categories (science, practice and the transdisciplinary process) consist of three sub-categories, making a 3 × 3 structure.

The categories and their relations are also established through color. Jahn (2005) uses green and purple for science and practice and pink and grey for the middle. Lang et al. (2012) put the sub-categories in boxes of a distinctive (shades of blue). Cockburn et al. (2016), see Fig. 3, make practice light red and science yellow. In the middle section they come together, which is depicted in orange. Hoffmann et al. (2019), see Fig. 4, similarly, use shades of blue, suggesting more limited differences between practice and science. Pohl et al. (2017) use different shades of green for practice and science (green), and they make the transdisciplinary process in the middle red.

Finally, concerning the textual labels, a shift takes place over time. In an early visual, Bergmann and Jahn (2008) list specific actor groups involved, problems encountered, and results attained on both sides, yet strip these details when they move to explain a more abstract version of the visual. Visuals published some years later (Lang et al., 2012; Jahn et al., 2012; Cockburn et al., 2016) again specific actor groups. After

² Only in Brink et al. (2018) and Lam et al. (2021) the three categories are less clearly distinguished. They put the stress, respectively, on the phases of the process and the context of the process.

Abb. 2: Transdisziplinärer Forschungsprozess II

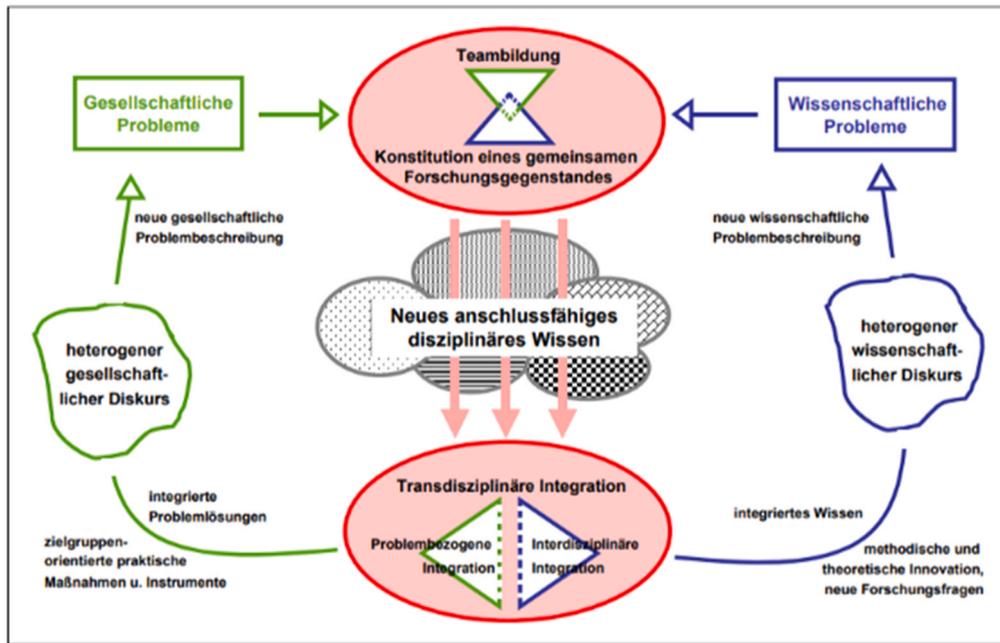


Fig. 1. Second figure in Jahn (2005). Original can be found here: <https://www.tatup.de/index.php/tatup/article/download/3456/6221>

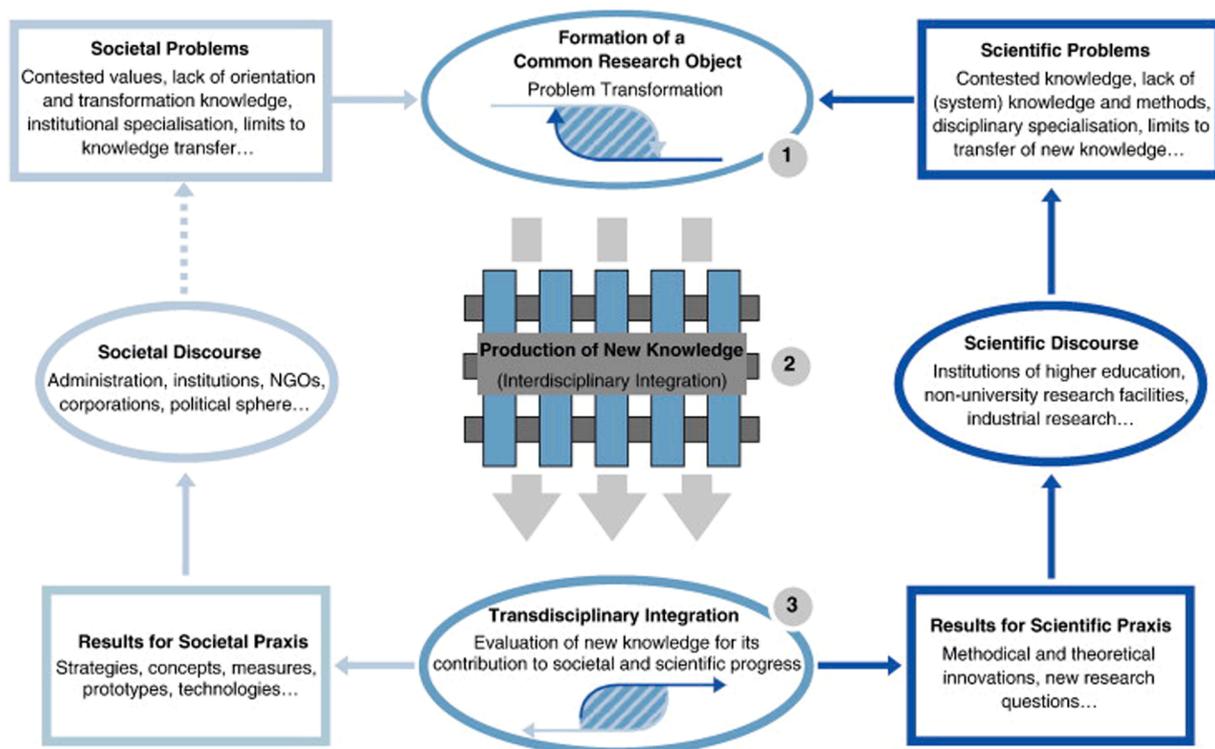


Fig. 2. Figure in Jahn et al. (2012). Original can be found here: <https://doi.org/10.1016/j.ecolecon.2012.04.017>

this, the labels used on the two sides of the visual drop the specifics and, this way, make both sides look more homogenous. Pohl et al. (2017), Brink et al. (2018), Hoffmann et al. (2019) and Lam et al. (2021) each have minimal textual detail about what happens on the both sides. In the set of visuals as such, the categories of science and practice, their difference and coming together in collaboration is taken for granted. The publications (both visually and verbally) zoom in what happens in the

middle.

A focus on the middle - In the middle of each visual (the vertical axis), we encounter what is labelled the “transdisciplinary research process” (Lang et al., 2012). What happens there is the textual focus of most publications, even though in the visuals as much space is allocated to what happens on the both sides. The visuals depict this middle and label the separate sub-categories in it in similar yet different ways. The

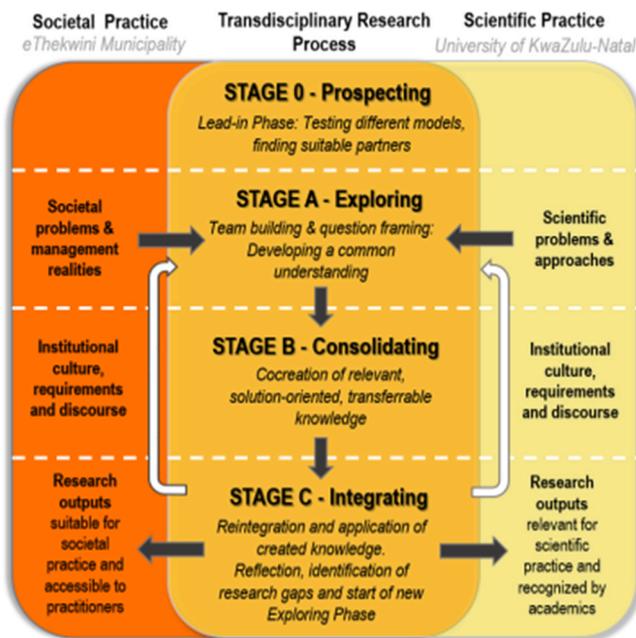


Fig. 3. Figure in Cockburn et al. (2016). Original can be found here: <https://www.jstor.org/stable/26270334>

similarity over the years in the visuals, is the use of three boxes; the labels used are different. Of particular interest, both in terms of imagery and labels is the heart of the visual (the middle of the middle). Jahn (2005) puts ellipses of different sizes in the heart with arrows going through them. What the heart consists of is visualized most explicitly in Bergmann and Jahn’s (2008) empirics-based visual. There, they create what we might call a gate, with arrows running vertically and rectangles running horizontally. Each of the arrows is connected to an actual disciplinary sub-project that took place in the project, while each of the rectangles signifies stages in the research process.

In the theoretical visual in Bergmann and Jahn (2008), the textual specifics are removed, and what remains are the arrows and rectangles and a box with one label. What thus only got into view in Bergmann and Jahn’s (2008) first visual is an indication of stages (depicted through horizontal rectangles) and also more concrete insight into what is going on at the heart of transdisciplinarity research: a set of sometimes distinct disciplinary research projects often within or under the heading of one project (depicted through vertical rectangles). Finally, Lang et al. (2012) use a zig-zagged line on top of the gate that previous figures use, denoting varying degrees of actor involvement. In the later visuals, the gate has vanished, and the middle consists of three similar boxes (e.g. Hoffmann et al., 2019; Lam et al., 2021). In Box 1 we provide more detailed description of categorization in specific publications.

4.2. Narration: double-joint cyclical narrative

The visuals also *narrate* the process of transdisciplinarity. The boxes

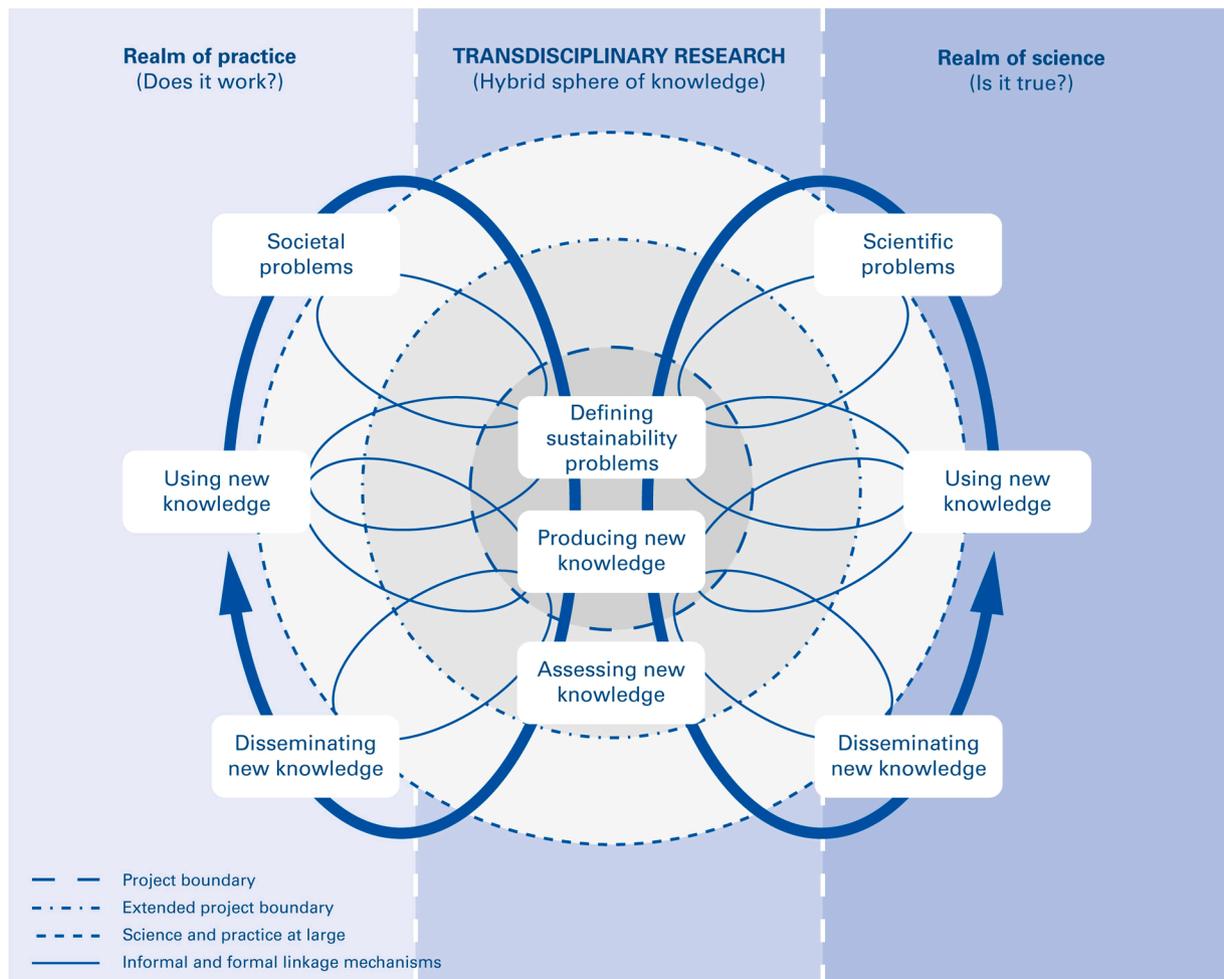


Fig. 4. Figure in Hoffmann et al. (2019). Original can be found here: <https://doi.org/10.1016/j.envsci.2019.08.011>

Box 1

Categorizing in four example publications.

[Bergmann et al. \(2005\)](#) include categories of everyday life problems and scientific problems on each side of the visual. There are heterogeneous categories, including elements of the problem and methodological approaches in the research team. Interestingly, like in [Jahn \(2005\)](#), team building is included in the visual, suggesting differences between team members. Stage B in this visual notes the “division into heterogeneous perceptions of the problem” - noting heterogeneity, alongside arrows denoting a flow of knowledge including intervention, differentiation and integration, often at the same time as a dual push-pull. We see that different parts of the project need to be aligned and brought together.

In [Jahn et al. \(2012\)](#), see [Fig. 2](#), societal problems and scientific problems are placed in boxes on either side of the visual as sides that contribute to the formation of a research object. Scientific and societal problems are detailed in the visual, for instance, noting contested values and lack of transformational knowledge. Societal and scientific discourses are also detailed, listing a range of actors, e.g., institutions of higher education and non-university research facilities. Third, results are also detailed, e.g., including strategies, concepts, measures, prototypes and technologies. The production of knowledge (interdisciplinary integration) sits in the middle, visualized as a “gate” with horizontal and vertical lines. The stages of research are added in this visual.

In [Pohl et al. \(2017\)](#) key concepts include the Realm of Science, rigor and understanding (is it true) and the realm of practice, relevance and design (does it work). ‘Is it true’ and ‘does it work’ are new additions, adding detail to the two sides, along with the statement that practice is interested in “workability”. In the visual description, this difference is further embedded in the use of the terms “rationality” and “thought school”. Transdisciplinary research is in the middle, described as functional - a dynamic collaboration of disciplines and societal actors to investigate and handle sustainability issues. The term functional dynamic is also new when compared to both 2012 articles. There is limited detail in this figure when compared to others, such as [Jahn et al. \(2012\)](#) and [Lang et al. \(2012\)](#).

[Hoffmann et al. \(2019\)](#), see [Fig. 4](#), add new information to the realms of science and practice, asking ‘does it work’ and ‘is it true’. Transdisciplinary research is also labelled as a ‘hybrid sphere of knowledge’. This visual emphasizes boundaries more when compared to the previous images, as exemplified by the legend in the visual, which includes project boundaries and extended project boundaries. The text in the visual is also limited in detail compared to the others. The shapes have changed to show flexibility (exemplified by curves and round lines), which gives the feeling of flow and ease. In doing so, this visual breaks from past visuals, i.e., [Jahn et al. \(2012\)](#), which is square. Transdisciplinarity is in the middle—a visual core and layers around it. Practice and science become subordinate to it.

In summary, these examples demonstrate a twin move in the visuals. On one hand, science and practice become distinct and separate entities, and on the other, ideas about science and practice and what they aim for become more specified yet simplified in ideal types, as details of actors are lost. The focus begins to move from the outside of the visuals to the middle, where transdisciplinarity is suggested to happen—the core of the matter.

we just talked about signify events, sub-categories like actors and wider settings for the narrative. Narratives have a beginning, a middle and, if they are finished, an end. In the publications we studied, visuals set up a narrative of transdisciplinarity - its flow of events denoting how it takes place in particular settings. We see that the first visual ([Jahn, 2005](#)) sets up two narratives, one starting in science and the other in practice. Both narratives (actors: science or scientists and practice/society or practitioners) soon join in the middle (setting: transdisciplinary project) and then go their separate ways again after the transdisciplinary knowledge is produced. The actors end in the setting where they started, bringing new knowledge. The arrows here indicate activities or movement, yet they are not specified with labels in the visuals, only in the (verbal) text of the publication. The boxes on both sides indicate sub-categories (societal problems, results) that are moved with or by the arrows.

Only the first visuals in [Jahn \(2005\)](#) and [Bergmann et al. \(2005\)](#) have two clear beginnings and ends. The second visual in [Jahn \(2005\)](#) connects the categories in a cycle. Each visual in our set of publications after 2005 includes two cycles, with arrows linking boxes. The visuals all offer what we could call a *double-joint cyclical narrative* ([Jahn, 2005](#)). *Double* because there are two identical narratives. *Joint* because the actors meet in the middle to work together. *Cyclical* because in the visual the narratives go on in an ever-ongoing cycle, suggesting a never-ending story. In short: discourses are turned into separate problems, which are turned into shared problems (also called common objects), which are turned into new knowledge(s), which are turned into results that are used in both initial settings, where the cycle can start again.

Upon first sight, however, the flow is in one direction, yet there is not one beginning or end. The multimodal aspect of the articles (co-presence of verbal and visual) is important in finding the start of the narratives. The verbal texts of the publications do not represent transdisciplinarity as a never-ending story. They talk about transdisciplinary projects, which begin on both sides with the scientific and societal discourses.

This does raise a question that the visuals do not: The verbal texts suggest transdisciplinarity starts when the research questions are developed. In most of the visuals, attention is drawn to the joint part of the narrative, with a sequence of events taking place in the middle highlighted with numbers 1, 2, 3 or with A, B, C. This allows the reader to better understand the visual while reading the verbal, and vice versa. It also confirms that the part of the story that matters most is the joint part. [Lang et al. \(2012\)](#) - in the verbal text - suggest the way through which this joint part should take place, arguing that although we might think otherwise, the individual phases and overall sequence of the stages and processes of transdisciplinarity have to be conducted in an iterative or recursive cycle. Building on this idea, [Pohl et al. \(2017\)](#) and [Hoffmann et al. \(2019\)](#) visualize such iteration and include it as a central feature in their visuals.

The narrative move that [Pohl et al. \(2017\)](#) make - simplifying the narrative of what happens on both sides and complexifying the inside - is in line with what the publications actually are about: the middle is what matters most. Transdisciplinarity is about the co-productive part of the narrative. [Jahn's \(2005\)](#) narrative set-up of the visual (two sides that join, and not just the joint part) makes for a disbalance between the verbal content of most articles and the visual. As we can see, those visualizing after [Jahn \(2005\)](#) make visual moves around this set-up. Up to [Pohl et al. \(2017\)](#), we find that the boxes on the two sides contain activities and objects that get little attention in the verbal text. Finally, in various visuals (e.g., [Jahn, 2005](#); [Lang et al., 2012](#)), at the start of the joint part of the narrative (upper box in the middle), we also encounter the label team building. This suggests a parallel, social process that needs to take place for transdisciplinary research to be successful. The label, however, is not used in later visuals ([Hoffmann et al., 2019](#); [Lam et al., 2021](#); [Blind, 2024](#)). In [Box 2](#) we provide more detailed description of narration in specific publications.

4.3. Idealization: the normative dimension of visuals

Finally, there is a descriptive and a normative or ideological dimension to the visuals. Looked at descriptively, the visuals depict the entities that transdisciplinarity consists of and how these relate. In a number of the publications analyzed the visual is called an “ideal-typical” description (e.g., Lang et al., 2012; Brink et al., 2018; Hoffmann et al., 2019), which makes sense for models as such. As a simplification, a model brings out what matters. Looked at normatively, the visuals also include and highlight the process as it ideally works. Not all actual projects work like this, but this is how it works if it works well. In some publications, in line with this, the model is called “ideal” (e.g., Jahn et al., 2012; Lam et al., 2021), and not ideal-typical. The visuals simplify the process to get to the core, the shared narrative and also include an *ideal* narrative of collaboration.

This leads us to another ideal that can be read from the visuals: that of equality. As noted, from Jahn (2005) onwards, all visuals depict the two sides and their two categories, science and practice, as symmetrical. Visually, both sides get equal weighting and significance. The visuals portray them in a balanced manner; each side contains as many entities (boxes, arrows) and as much space. One is not depicted as initiating or more important (which might be done, for instance, by placing one of the two above). The equality stands out clearly in the visuals but remains mostly implicit in the verbal part of the publications. We would suggest this is implicitly assumed and an underlying principle of publications on transdisciplinarity: science and practice contributing, collaborating and reaping benefits based on equality. The double of the double-joint cyclical narrative is not just simplifying, it also depicts in accordance with an ideal narrative in which two groups of actors are equally involved in and important for what happens.

5. Discussion

In this paper, inspired by the socio-semiotic approach to visualization, we examined a set of visuals of transdisciplinary research that was published over the last 20 years. We sought an answer to the research question: *how do visuals give meaning to transdisciplinarity?* We looked at individual visuals in the context of publications and compared them

over time. In summary, our analysis tells us that the elements of transdisciplinarity have been visually categorized through three main categories: science and practice on two sides and a transdisciplinary research process in the middle. Through time the transdisciplinary process in the middle became the focus of the visuals and the publications they are embedded in, although visuals diminished in informational content on it. In terms of narrating, we identify a stable double-joint cyclical narrative. The narrative of transdisciplinarity starts in the settings of science and practice (as separate realms), after which scientists and practitioners as actors join to collaborate, then depart with the results of the collaboration, after which a new episode of the narratives can start. Finally, an implicitly assumed principle that is visualized, is the idea and ideal that science and practice are contributing, collaborating and reaping benefits based on equality.

5.1. Categorization, narration, and idealization

Now we will discuss the main findings of the analysis in the light of the wider literature on transdisciplinary research. First, the visuals categorize science and practice as two separate realms or spheres and, through time, initially became stronger. Although there were visuals that included labels that indicated different actors on both sides, later visuals suggested homogeneous processes. Yet practice and science are heterogeneous (Lawrence, 2023). Although this has been known for a long time (Gibbons et al., 1994), Jahn et al. (2022: 352–3) recently observed that “approaches to transdisciplinarity often imply a conceptual dualism of science and society.” Earlier, Harris and Lyon (2013) paid attention to different professional cultures and looked at collaboration between different groups within science, which, of course, also consists of practitioners (Knorr Cetina, 2001). Moreover, we found that in the earlier publications in which we encountered the visual, there was more attention to the interdisciplinary nature of scientific contributions in transdisciplinary research. This was visualized as an important part of the integration that had to take place at the heart of transdisciplinary research. In the more recent versions of the visual, this has disappeared. In one of the early visuals, the only one that visualized an actual research project (Bergmann and Jahn, 2008), the distinctive disciplines made it to the visual. This suggests that over the years, the process of integrating

Box 2

Narration in four example publications.

Cockburn et al. (2016) is the only visual that has a stage 0, a stage that comes before the inception of the research. In their visual they show that there is a lead in phase with there is a testing of different models and a finding of suitable partners. However, stage 0 is not made part of the double-joint cyclical narrative, as there are no arrows leading to it or coming from it. It is hovering above the research project.

Pohl et al. (2017) further develop the double-joint cyclical narratives adding extra layers of movement. They turn the sets of arrows, flowing to the inside, joining in the middle and going their separate ways, into two big arrows, in passing simplifying the three entities and four arrows on each side into one entity (an event/activity: science/society investigates/handles sustainability issues) and two arrows (a bigger and a smaller one) on each side. Transdisciplinary research, the middle, by contrast, is made more iterative and circular, with arrows going back and forth between the entities.

Hoffmann et al. (2019) make some further narrative moves. While visually building on Pohl et al. (2017), comparing the two shows Hoffmann et al. (2019) replace the two inner circles and the back-and-forth arrows with eight ellipses, suggesting a lot of in-between activity within the larger process. This way they want to signal, as the verbal text confirms, the iterative nature of the transdisciplinary research process. In addition, they bring back narrative complexity to what happens in the realms of practice and science, going from one sub-category to three. This is in line with the focus of the article on knowledge utilization that two of the three sub-categories help depict (the third sub-category involves just going back to what was in the 2012 visuals: societal/scientific problems).

Whereas the 2012 articles, in particular, are focused on the middle, Lam et al. (2021) keep the double-joint cyclical narrative but draw attention in big to the settings where the narrative begins (contexts) and ends (effects in society and practice) of the narrative. The basic narrative they present in the visual, assembling elements from various publications (Jahn et al., 2012; Lang et al., 2012; Pohl et al., 2017), is kept the same. However, in the verbal text, it is taken for granted, flipping around the attention from the middle to the sides. In the verbal narrative, however, the attention to the beginnings and the ends is not to stress the difference of practice and science as settings in the narrative, so to speak, but to highlight the uniqueness of the particular practice and science settings (e.g., western science, global south). The narrative basic narrative structure is kept the same, while they stress that *every* transdisciplinary project story has (or needs) different beginnings and ends.

knowledge from the different disciplines has become less of a focus in the debate on transdisciplinarity, yet we might wonder whether the challenges in practice have diminished.

Second, building on the categorization of science and practice, the visuals include the double-joint cyclical narrative as the core of the transdisciplinary research process. Again, this narrative path is set by the first publication (Jahn, 2005). This does not mean that there are no attempts to develop the narrative to signal elements of the actual practice of transdisciplinarity that have been ignored. Hoffmann et al. (2019), for instance, theorize transdisciplinary research projects as processes that involve many iterations and interactions and that they run through their phases “in a disorderly manner and progressively extend their boundaries into the realms of both science and practice when assessing and disseminating new knowledge” (Hoffmann et al., 2019: 39). This is also what can be seen in their visualization, with at the heart a set of circles signal extending boundaries and ellipses that point at iteration or ongoing interaction. Some dimensions of the joint part of the narrative that were at one point visualized got lost, like the social dimension that was signaled with the label of “team building” or the variation in collaboration that was depicted with a zigzag-line (both in Lang et al., 2012). Another issue is that of the cyclical nature of the visual narratives, that contrasts with the verbal texts talking about transdisciplinary projects with a clear start and a clear end. However, with Cockburn et al. (2016) we see and attempt to include the more particular start of a project in what the literature suggested as a phase 0 (also Horcea-Milcu et al., 2022). At the same time, there is something more cyclical about the reality of transdisciplinarity, in that projects build on previous made connections (McKee et al., 2015).

Third, the visuals display transdisciplinarity in an ideal-typical and ideal manner. This is what Knorr Cetina (2001) tells us to expect. Researchers create models that are simultaneously *of* and *for* reality. The visuals make a normative leap (Rein and Schön, 1977), prescribing how transdisciplinarity should be. Furthermore, if we look at how the two main actors are categorized and the process is narrated, each visual implicitly idealizes transdisciplinarity as a process in which science and practice are equally involved and important collaborators. The visuals are totally symmetrical. This idea of transdisciplinarity can also be found in the verbal dimensions of the publications we studied and well-known publications on transdisciplinarity, like Gibbons et al. (1994), who stressed the non-hierarchical nature of transdisciplinary research. Yet in some of the publications we studied and in many other recent publications on transdisciplinarity we encountered critique of this idea by emerging literature on power in research collaboration and transdisciplinarity. Flattening of power at least in an ideal form is important for transdisciplinarity as power disbalance can for instance hinder the practicality and suitability of local solutions. While the power differences are heavily debated in the literature on coproduction of knowledge, for example (e.g., Klenk and Meehan, 2017; Turnhout et al., 2020; Kareem et al., 2022), the visuals we studied are concealing power differences and tensions between those involved in transdisciplinary research.

5.2. Copy, appropriate, or develop

The categorization, narration and idealization together point to aspects of transdisciplinarity that the publications are focusing on. They also need to simplify and reify parts of real-life processes. Lam et al. (2021) visual is an excellent example to illustrate this. The focus is moved to beginnings and ends, taking the established categories and narrative for granted. If we take a step back and look at the discussions on transdisciplinarity as an epistemic object, the research into transdisciplinarity complexifies it, as Knorr Cetina (2001) suggested. Imagine combining all the visuals, with all their details, into one master visual. That is what the visuals in dialogue amount to, one might say. However, what also gets attention in broader academic dialogue, yet not really in the visuals, are difference and tension. To prevent, for instance, power

differentials and instrumentalism (Turnhout et al., 2020; Fritz and Meinherz, 2020), “transdisciplinary environmental science must recognize and value difference as much as it strives to produce policy-relevant knowledge” (Klenk and Meehan, 2015: 166).

We also look at the level and kind of changes that are made in the visuals overtime. If we compare visuals, we see that visuals could be placed on a scale ranging from *developing* at one end (e.g. Pohl et al., 2017) and *copying* at the other (e.g. Pohl et al., 2021). In the middle between these two ends, we find *appropriating*. We have not included the “pure” copies in our analysis. Many visuals are copying big parts of earlier visuals yet appropriating them by adding a particular element or leaving things out (e.g. Blind, 2024). That might lead to a mismatch with the verbal part of the paper, as it might not discuss the basic structure itself (e.g. Lam et al., 2021), while that is prominent in the visual. Only a few visuals substantially develop the visual depiction of transdisciplinarity, to bring theoretical ideas to the fore that signal a more fundamental change in the epistemological object. Pohl et al. (2017) and Hoffmann et al. (2019) mostly clearly brought development. Yet these two, because of their abstract nature and low level of differentiation through labels, are less informative of the object than previous visuals (e.g., Lang et al., 2012).

5.3. Back to the verbal, create alternatives, or thicken descriptions

Transdisciplinarity as an epistemic object is not simple, stable and singular. It is complex, emergent and multiple. While conceptual visuals in principle help to simplify and stabilize, we also saw efforts to include more complexity and multiplicity in them, for instance in the label-rich visuals that spelling out distinctive actor groups (e.g., Lang et al., 2012) or a parallel process of team building (e.g., Jahn, 2005) and in a visualization closer to an actual project (Bergmann and Jahn, 2008). Nevertheless, any attempt to map an epistemic object for good fails (Knorr Cetina, 2001), whether in a visual, in the publication a visual is embedded in or even the entire academic dialogue these publications form.

Is it fair, then, or even still needed, to point at the constitutive work of visuals in this, instead of just accepting and celebrating their pragmatic accomplishment: seeing main elements of transdisciplinarity and their relations in a way that offers overview, is easy to remember and share with others? We believe it is. The visuals put in place certain elements and their relations. They are attempts to represent transdisciplinarity for a single view, with descriptive and normative implications. They help constitute or enact transdisciplinarity (Law and Urry, 2004). We found a core categorization, narration and idealization of transdisciplinarity overtime, while the visuals vary around this core as particular aspects of transdisciplinarity as an epistemic object that have not been in focus (for a while) get attention and new tracks of research develop (Knorr Cetina, 2001: 187). In the visuals studied we see two equal actors engaging in a joint narrative. We also saw differences, often subtle and became aware of the tension between the visuals and the practice they depict. It is helpful to point at the logics and limits of visualizing, and to tease out the continuities and discontinuities over time. Transdisciplinarity, as an epistemic object, is constantly mutating into something other than what it was at one point in time. This also challenges us to think through alternatives and improvements of present practices.

A. *Verbal over visual* - The publications in which the visuals are embedded contain much more information than can find its way into a visual. One might suggest, therefore, that complex processes are better caught through verbal means (Tsoukas, 2017). However, in the end, text will fail as well, and visuals help our understanding (Knorr Cetina, 2001). The danger, then, might mostly be found in the way they are interpreted and the way they develop with the broader understanding of transdisciplinarity that we can find in the literature. If they are interpreted as accurate depictions and retain a core that is merely an ideal or an aspiration that those involved do not really live up to, they might

damage transdisciplinarity as a practice and obstruct theoretical progress.

B. Alternative visuals - Visualizing implies making choices in composition, color, positioning and more that have conceptual implications. The visual studied, for instance, did not place science or practice above the other, showed much heterogeneity within or beyond science or practice, or let the narrative flow from left to right (Gibbons et al., 1994; Harris and Lyon, 2013; Fritz and Meinherz, 2020; Angheloiu et al., 2023). In addition, the visual we analyzed did not always match the embedding publication. The best example of this is the visual attention given to the two sides (science and practice), while publications are mainly about what happens in the middle.

Different choices could be made that make for a different visual and thus conceptual rendering. Power differences, inconsistency and tension, for instance, could be better visualized. If we zoom out more, we see that more radically different understandings would lead to alternative visuals. Alternatives would probably be based on other metaphors, as they imply ways of seeing (Klenk, 2018). An example is Scholz et al. (2024), work with the idea of traffic lights. Another is Jacobi et al. (2022), who depict the transdisciplinary research process as a spiral. Similarly, Mol and Hardon (2020: 1) recently suggested replacing the dominant visual metaphor of interdisciplinarity with a “jigsaw puzzle in which each discipline adds a piece”. A final example is Klenk’s (2018: 316) suggestion to look at transdisciplinarity as meshwork, in an effort to “sensitize researchers to the value of emergent outcomes, differences between research objectives and unintended consequences, and relational skills of encountering, witnessing, and responsiveness.” Most clearly in Klenk’s work, the alternative is not just meant to describe transdisciplinarity better, but also to suggest how it could better live up to its promise of equal involvement.

C. Thickening visual description - Building on an interpretive concept (Geertz, 1973), a third practice is to create more visuals that help to thicken the textual description (van Hulst and Visser, 2025). In many publications in the field, we find multiple visualizations, each of which visually adds a layer of meaning and allows to show more of the complexity and multiplicity of transdisciplinary projects. This way, making publications more multi-modal, research increases its use of the strengths of visuals in giving meaning to epistemic objects. Pohl et al. (2017: 50; 2021: 21–24), for instance, include visuals that zoom in on the variation in composition and intensity of the collaboration. In addition, with this they do not visualize the ideal collaboration, but the collaboration as it actually took place.

In the end, we should embrace alternative visuals that better grasp the power differences, complexity, emergence and multiplicity of transdisciplinarity. Nevertheless, what is gained in one aspect might be lost in another. Alternative visuals are not necessarily (only) improvements. Visuals that want to do too much might end up confusing readers more than helping them. We might therefore also appreciate different and (seemingly) incompatible visuals side-by-side within one publication and in the wider literature. Beyond visualizing itself this can lead to elucidation of difference and tension in transdisciplinary projects and insightful dialogue about them.

6. Conclusion

Visuals of transdisciplinarity depict its main actors collaborating. What sense does it make to show that they do? A comparison of visuals with the embedding publications and findings in the wider literature helped surface similarities and differences, and a mismatch of visuals and the practice depicted. Our analysis showed that the visuals we studied depict the main actors and narratives of collaboration in a similar manner. We encountered a visual core that moves across boundaries in time and space in a way similar to what Latour (1986) suggested of maps. We showed that overtime visuals have picked up on an early attempt to catch the epistemic object of transdisciplinarity in one view, copying, appropriating and to some extent developing it

differently.

Our analysis also suggested that what is silently carried over is an ideal, not just of how transdisciplinarity should work but also of equality between its main actors, forming its ideological starting point. Both the simplifying ideal-typical and the normative work of visuals are in tension with the complexity of the phenomenon as it can be encountered in other ways. Our analysis thus demonstrated the subtle ways through which visuals give meanings to transdisciplinarity. We should not underestimate the importance of the kind of visuals we studied for either research or practice. They do not only have a central role in many well-read articles (Pradies et al., 2023), they are also part of trainings and project proposals (Pohl et al., 2017).

There are several limitations to our work here and opportunities for future research. First, we looked closely at one set of visuals. We encountered and made a case study of a visualization of transdisciplinarity that many readers have seen. It is not the study of all visualizations of transdisciplinarity (for diversity in visualization, see, e.g., Lawrence, 2023). Other visualizations of transdisciplinarity could be studied, or the visualization of other epistemic objects like the circular economy. Second, we analyzed the visuals and did not look for reasons that visualizers have for their choices in visualizing, the interpersonal dynamics in visualizing or at the creation of the visuals. Such a study, for instance, through interviews with the authors of the visuals, and through ethnographic fieldwork, would enrich our understanding of visualization and the conceptualization it is part of (Ewenstein and Whyte, 2009). Third, one might argue that there is a tautology in studying similar visuals and concluding they are similar. What we do is more subtle, however. We establish *what* is the shared elements and *what* varies around them. Nevertheless, what we do not know about is the relationship between the visuals we studied and the alternatives we encountered.

Fourthly, we suggest to consider the visuals developed in transdisciplinary research as boundary objects (Star and Griesemer, 1989; Metze, 2020; Cuppen et al., 2020; Lundgren, 2021). Considering them as boundary objects brings the focus to the interactions they afford and prevent. It might help us to explore the way visuals can enable an integration of different epistemologies and contribute to more epistemic justices in transdisciplinarity. Fifthly, we encountered the ideal of equality in collaboration. Recent research further problematizes the power inequalities in actual transdisciplinary research practices. We expect a lack of publications based on empirical research that visualize this. A in-depth genealogy of a broader set of publications on transdisciplinary research may help to tease out the ways in which transdisciplinarity has been conceptualized might also (unintendedly) have contributed to reproduction of inequalities. Finally, building on the previous point and our discussion, our paper should not be read as critique of visualizing as such. We hope the visualizers among us will visualize transdisciplinarity in alternative and thicker ways, for instance bringing (actual) power dynamics and tensions in view.

Visuals are important. We do not need less visuals, but more diverse visualization. It can play a vital part of the effort to understand transdisciplinarity. The kind of critical approach used here should lead us to better appreciate visualizing efforts and think of further ways to visually conceptualize transdisciplinarity. Transdisciplinarity is complex, emergent and multiple. When we describe, explain and shape it, we try to make it more simpler, stable and single. We do this in order to grasp and work with it, but it escapes us in the end. We try to witness it, partake in it and improve it, but it takes place in many locations simultaneously, is always in the making and takes different forms in project plans, activities, budgets, visuals, and more. We might well acknowledge all this, try to do justice to complexity, multiplicity and distribution, reinforcing our epistemological efforts to conceptualize transdisciplinarity and further improve its practice.

CRedit authorship contribution statement

Merlijn van Hulst: Methodology, Formal analysis, Conceptualization. **Kirsty Holstead:** Methodology, Formal analysis, Conceptualization. **Tamara Metzke:** Methodology, Conceptualization.

Declaration of Competing Interest

We have no conflict of interests.

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Data availability

The data are publicly available.

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