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From Trans-Disciplinary Research to Trans-Domain Approaches

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ABSTRACT [1]

The concept of transdisciplinarity refers to the historically grown organization of science – an issue of sociology of science – and hence is not suitable for epistemological concerns. Instead, it is proposed to broaden the concept and speak of Trans-Domain Approaches (TDAs). Domains are fairly homogeneous knowledge fields that are clearly distinct from other such fields on scientific grounds. A TDA consists either (a) in a General Theory (GT) that connects, integrates and transcends a set of Domain-specific Theories (DTs); or (b) for practical purposes, in an action model that describes how practitioners can deal with DTs in concrete situations, for which no general rules are available. The *Is-Ought* problem, an important topic in research and in practice, serves as example for the use of TDA. It is shown that *Is* and *Ought* are separate domains. In a decision how to act, practitioners need to take both *Is* and *Ought* into account and relate them with each other. Further, TDAs can form a hierarchy, which means that the DTs can become GTs of subordinate TDAs. Finally, it is argued that one single universal TDA does not make sense; rather, the TDA will depend on the research topic and the author's theoretical background.

Keywords: Transdisciplinarity, Trans-Domain Approaches, *Is-Ought* Problem, Action Theory.

1. INTRODUCTION

Transdisciplinarity is one of those iridescent terms in science that have almost as many definitions as authors writing about it [1; 2; 3; 4; 5; 6; etc.], and the literature on transdisciplinarity abounds: Our university reference system lists more than 5000 publications with transdisciplinarity and similar terms in the title, and in a meta-analysis [7], more than 26'000 papers dealing with inter-, multi- and trans-disciplinarity were used. The term *transdisciplinarity* has first been mentioned by Jantsch in 1947 [8], who participated also in a conference 1970 [9] with several other authors [10; 11; etc.]; the results of the conference are summarized as follows: "(S)ince we have recognised the problems raised by preparing a common language and comparing or even interlocking the methods, concepts, structures and axioms on which the different disciplines are based, we can no longer be halted on the road to unity. (…) In the course of our work there emerged a kind of general consensus for designating this move beyond the interdisciplinary stage by the name of *transdisciplinarity*." [12, p. 284, my emphasis]

The *goal of transdisciplinary* research is to provide as much insight as possible about a research topic, notwithstanding the boundaries that may exist or have been erected between different fields of research. There are serious research problems that are very complex, and all sectors of society must cooperate to solve them [1]: The main problems with which humanity is confronted do not follow disciplinary boundaries. The only condition for transcending the boundaries is that the insights are gained scientifically. Since in different scientific fields often different theories of science are defended, I use a very generic concept of science, namely (1) replacing truth by *viability* [13; 14], which refers to whether a theory or another concept is useful in accomplishing its task (in this case, providing insight on the research topic), and (2) critical warranted assertibility: *Warranted assertibility* ([15, based on 16; see also 17]) means that the scientists support their statements with arguments in all conscience and in accordance with the criteria and methods of the respective scientific community, and based on (repeated) inquiry cycles; it seems necessary to add that the warranted assertibility must be *critical* in that this argumentation is systematically questioned, which permits the development and evaluation of scientifically justified new approaches or methods. It is important here to mention that the use of theory is not restricted to descriptive frameworks based on empirical research (*Is*), but includes normative statements based on ethical considerations (*Ought*). Both types of theories aim at viability, although the viability criteria are different, and both are subject to critical warranted assertibility, with different means to ascertain it (see section 4).

However, *disciplines* are inappropriate to distinguish fields of research since they refer to a sociological, not to an epistemological framework. Instead, the concept of Trans-Domain Approaches (TDA) is proposed (section 2). A framework for a theory of TDA is presented in section 3, and as a prototype, TDA is applied to the *Is-Ought* problem (section 4). Section 5 deals with the relations between TDAs. In the last section, some conclusions are drawn.

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2. DEFINITION OF TRANSDISCIPLINARITY AND TRANS-DOMAIN APPROACHES (TDA)

For the discussion of any scientific topic, it is important to clearly distinguish the definition of a concept from its theory. Roughly said, in a *definition*, one uses a shorter wording to replace a longer one [18]. A *theory* consists in a set of statements that can be checked for viability, particularly whether it can help solving problems (in traditional theory of science one would say: whether it is true or justified). Definitions add little or no content (or information) to what is already given; the criterion for a good definition of a new concept is its utility for theory-building. For a theory, the claim is that it is non-singular, i.e., at least partly universal, i.e., viable for more people, situations, times, behaviors, etc., than for which it has already been tested or argued for. Compared to the available support, whether argumentative or through evidence, it has a surplus of information which is achieved through induction. The conclusions based on such induction can be checked for viability. To conceive, enhance, and test such theories is the primary aim of research.

Given the heterogeneous use of the term *transdisciplinarity*, a unifying definition seems necessary that covers most of them to a certain degree and is useful. This means that while the concept is defined as precisely as possible, not too many restrictions are put into it to keep it flexible; these restrictions are better dealt with in a theory of transdisciplinarity. Therefore, I propose the following definition: Transdisciplinary research is a scientific approach with capitalizes on an integrative reciprocal referentiality between and beyond fields of knowledge with the goal of providing as much insight as possible about a research topic. This definition is more precise than, for instance, the often-cited definition as "an approach to transcend the disciplinary bounds inherent in multi- and interdisciplinary research" [19, p. 1343]. The principle of integrative reciprocal referentiality is still quite open; its concretization will depend on varying issues, all of which must be considered as scientific in the sense of critical warranted assertibility. More details will be provided below in the theory (section 3) and in a concrete example (section 4).

2.1 Transdisciplinarity as action and as system of statements

In the literature, one can find two types of definitions of the term *transdisciplinarity*: as action and as system of statements.

Transdisciplinary research as *action* can refer at least to four issues: organization, people involved, methods, and communication.

- The *organization* of the universities was the main topic of Jantsch's publications, e.g., "With transdisciplinarity, the whole education/innovation system would be co-ordinated as a multi-level, multi-goal system, embracing a multitude of co-ordinated interdisciplinary two-level systems, which, of course, will be modified in the transdisciplinary framework." [9, p. 105] This issue has been taken up repeatedly (e.g., [1]). The organization of research is also affected by issues of transdisciplinarity, as national funding organizations are typically organized by disciplines, whereas calls for research proposals, e.g., by the European Union are often transdisciplinary [20]. And business organization can apply transdisciplinarity as well (e.g., [6]).
- *People*: There seems to be agreement among authors that in transdisciplinary projects, several researchers with different backgrounds cooperate on a common project over an extended period (e.g., [19]). Some authors emphasize the participation of practitioners of the respective fields [21; 22] and internal and external stakeholders as well [23; 24], etc.
- From the point of view of *method*, transdisciplinarity has been called a form of carrying out research [25], a methodology [21], an attitude [1, section 1.2.1], and so on. All these methods have in common, that in some ways they combine scientific insights (scientific theories) from different fields (disciplines) through some activity, sometimes in combination with everyday practical experiences or practices. This requires identifying the differences between the respective approaches, concepts and theoretical frameworks; only then, it is possible to link them with each other [26, p. 25]. And finally, the methods serve to achieve scientific viability of the statements or practice.
- *Communication* becomes a crucial issue when people from different fields work together, as already mentioned above in the conclusions of the conference 1970 [12, p. 284]. Communication is always based on subjective theories, which can differ considerably for representatives of different fields, thus the risk of misunderstandings is high unless precautions are taken, like providing clear definitions which are not necessary within disciplines as there is already agreement about the respective theoretical bases [27].

The different types of transdisciplinarity as action can be related; for instance, a concept that combines the different issues is the distinction of three stages: co-design, co-production and co-dissemination [28]. In business, organizational transdisciplinarity means involving various stakeholders from in- and outside the scientific world [6]. This is a possibility, but not a necessity: The criterion for good transdisciplinary research is not who participates, but whether an improved understanding of the problem compared to a single-domain approach is achieved.

Transdisciplinarity as *system of statements* refers to theory. According to an often-cited definition it is a theory that integrates and transcends the different perspectives of the respective fields or domains [19]. In contrast to *inter*disciplinarity, in which the different fields or domains coexist, without being integrated into a superordinate structure, in *trans*disciplinarity the statements contain something extra that connects different phenomena; it can take the form of a General Theory (GT) that combines but does not replace a set of specific theories addressing the same topic of research ([5, p. 53]; see also [25]; and others). Details of this will be the topic of the theory of transdisciplinarity (section 3 below).

2.2 Disciplines vs. domains

Trans-Disciplinarity consists of two parts: Trans and Discipline. The former has already been addressed above as integration and adding something new to the sum of specific theories. The latter, *discipline*, is highly problematic and hence inappropriate (in the sense of the usefulness of the concept). The following problems have been addressed:

- Disciplines are "diffuse types of social organizations for the production of particular knowledge" [29, p. xiv];
- they define themselves and can be defined in several ways [30];
- they serve to defend territories within the scientific community [31, p. 28];
- they have institutional consequences [25];
- they are biased, e.g., by a Western (and often Eurocentric) concept of a valid approach to knowledge [32];
- they underwent strong changes in history, as some disciplines disappeared, and most of the remaining underwent increasing specialization [33, p. 56];
- the term discipline refers to the historically grown organization of science and is not a stable category (e.g., [25, p. S71; 34, pp. 51-57]): Fields that were within a discipline some years ago may have separated to form different disciplines today, which may happen differently in different universities;
- today's disciplines are so heterogeneous and defined differently that it is impossible to find common denominators and boundaries [30];
- the disciplines are interrelated in different ways, and the science system is considered "as non-linear, but turning on itself in an endless spiral, to say nothing of the numerous inter-connections among the terms" [11, p. 131]; some of the disciplines have partly asymmetrical dependences (natural sciences), others have no such hierarchies (social sciences), and both types are related, the latter being much more complex, building on the former, but not reducible to it.

Disciplines refer to social structures, to be addressed in sociology of science [30], and the epistemological quality is secondary, if it plays a role at all. Since the present paper is not concerned with the organization of science but with the aim to gain as much knowledge and insight as possible about a research topic, I will refrain from using the concept of discipline. Instead, I use the term *domain*, thus referring to the concept of domain knowledge, which means semantic knowledge for a particular field [35, p. 660] – that fits exactly the present purpose. Instead of the term transdisciplinarity, I will use the term Trans-Domain Approach (TDA); this acronym will refer to the system of combining domains, corresponding activities, etc.

A *domain* is here defined as a research topic or thematic field that is addressed with a homogeneous system of related theories and studied with similar methods; these theories will be called Domain-specific Theories (DT). This definition is kept open to permit the application in different contexts. In particular, the focus will not be on the domains themselves, but on the lack of obvious relations between two or more domains. TDA is defined as *a system of scientific statements that relate the theories of different domains and adds new issues to the ones already contained in the respective domain-specific theories to achieve a goal that cannot be reached within one domain.* [see 19; 25; 36; 37; 38] The different aspects of this definition are addressed in a theory of TDA.

In certain contexts, disciplines can be interpreted as domains; hence it is possible to relate TDA to the discussion on transdisciplinarity. But it is also possible to connect TDA with related approaches which do not refer to disciplines, like paradigm multiplism [39], critical multiplism on all levels [40], and others. Replacing *transdisciplinarity* by TDA prevents many problems linked with disciplines. Nevertheless, the term transdisciplinarity is kept in the paper title and keywords to connect with the corresponding literature.

3. SOME ELEMENTS OF A THEORY OF TDA

A theory of TDA is a theory about the research topics (section 3.2), the DTs and their distinctions and relations, the GT, which can take the form of statement (section 3.1) or of action (section 3.2) and its relation to the DTs, etc.

3.1 TDA as system of statements

The theory of TDA ([5, p. 53]; and many others) states that a TDA as system of statements is conceived as follows, as illustrated by figure 1: A TDA consists of a scientific system of theories that includes a GT that connects, integrates, and transcends a set of specialized (domain-specific) theories (DTs), but does not replace them. This goes beyond a simple combination of the domains (which would be called interdisciplinarity or inter-domain approach); rather, the GT contains more information than can be found in the combined theories of the respective domains or DTs alone, but does not include all information contained in the respective DTs. The GT, hence, is a superordinate theory (for the principle of super- and subordinate theories, see [41]). The DTs, in turn, address some issues of the research topic with more details but narrower bandwidth than the GT as they focus only on certain issues and do not consider other ones that, from the perspective of TDA, would be important as well.

In this concept, there is only one restriction with regard to the GT, the DTs, the boundaries between the domains and the relations: They must be scientifically justified (see above, critical warranted assertibility), since TDAs are scientific concepts. There is no general rule how the domains are distinguished and how the relationships between DT and GT are conceived. According to this theory, TDAs are not restricted to one only way of doing science; rather, different theories of science can be used and the respective theories integrated into the GT [40] to compensate mutually for deficits or for other reasons.

Also, one cannot provide a universal system of domains; rather, the domains to be integrated will depend on the

topic of research, and the conception of the domains can differ from one topic to another.

One can even imagine that what counts as a domain in one TDA can be divided into two sub-domains in a sub-TDA, thus constituting a hierarchy of TDAs with superordinary and subordinary TDAs (already in [43, p. 410]: multilevel coordination; see below, section 5). The distinction of super- and subordinary theories refers here to meta-theories, not to object theories as above the relationship between GT and DTs. Such a hierarchy of TDAs has been done, for instance, for Values *and* Knowledge Education (V*a*KE) [42]: In a first TDA, the two domains and respective DTs *knowledge* and *values* are related with each other in a GT (see also below, section 4); in this case, the domains are conceived through different meta-theoretical frameworks (*Is* and *Ought*). On a second level, each of the two domains is conceived as a new sub-TDA, one for values (different types of conceptions about values as DTs) and one for knowledge (different knowledge fields as DTs).

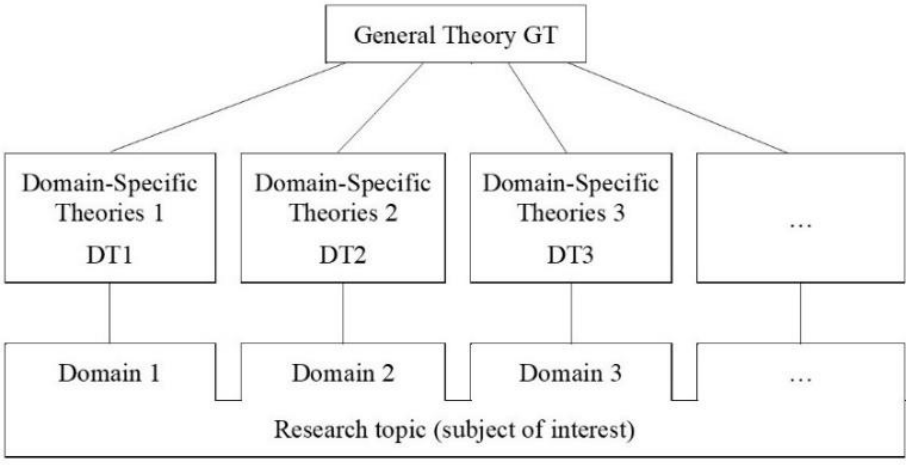

Figure 1: TDA as relationships between General Theory (GT), Domain-specific Theories (DTs), domains, and research topic (adapted from [42, figure 1])

The target objects – the topics of interest – are different in the super-TDA from the ones in the respective sub-TDAs. This is appropriate because the TDA is not an aim in itself, but serves to address a research topic – in the case of V*a*KE, these are different issues of a dilemma in which different values as well as different knowledge contents are addressed. The analysis [42] confirms that this theory of TDA is viable for addressing V*a*KE and provides further insight into the values-knowledge relationship, into the relationships between the sub-domains of the values and in the one between the sub-domains of knowledge, all of this seen within an educational context.

TDAs can replace reviews of research, be it qualitative reviews, be it meta-analyses and meta-meta-analyses. Indeed, many of these reviews combine studies which, although dealing with the same research topic, address different domains and hence are based on different DTs. TDA is more systematic than qualitative reviews, while in contrast to meta-analyses, it is theoretically based, which permits more generalization since generalization (induction) is always based on theory.

An example for a GT is the Cognitive-Affective Processing System CAPS to account for behavior; it combines the following domains and respective DTs: *competence; perception; expectations; values; self-regulatory plans;* and *emotions* [44]. CAPS provides an umbrella (a GT) under which many theories (DTs) can be subsumed, concretized and integrated [40], with further differentiations (sub-TDAs); a DT of competence, for instance, includes intelligence and creativity, among others; for intelligence, in turn, different types can be distinguished [e.g., 45], thus constituting a sub-TDA.

3.2 Topics of TDAs

An important part of the theory of TDA refers to the research topics. Many topics cannot be captured within one domain, particularly those that are not exclusively scientific [46] such as challenges against mankind and the universe. In history, violence has been a constant problem in form of wars, unfair treatment of people and power abuse, etc. Then, environmental issues became an additional major challenge. And lately, the Covid-19 pandemic has uncovered weaknesses in the health systems, but also shown the power of concerted research across domains in conceiving vaccines (a medical – scientific – domain), vaccinating people, lockdowns, etc. (complex social issues relating to sociology, economy and politics, among others). Even if a concept is available that is viable at a given place or point in time place, it is necessarily local and temporary since conditions vary and change (e.g., varying attitudes towards vaccination and lockdowns; new versions of the virus), which requires adapted or even new concepts.

All of these challenges to humanity are complex, i.e., nonlinear, non-deterministic, dynamic with a substantial multiplication of relationships between the differentiated parts [47]; hence, scientific accounts and attempts to solve them must necessarily consider several domains in mutual interaction [25, p. S72]. Not the least reason is that all of these challenges involve – but are not restricted to – social and societal issues.

For these, TDA is particularly indicated. A presumed substantial advantage of using a GT compared to DTs here is that researchers hope to increase the scientific proficiency. For instance, a TDA might raise the explanatory power of descriptive DTs (which in the social sciences is pretty low, as a meta-meta-analysis has shown [48]) by using a GT that takes more variables into consideration than is possible for a single DT. Further, the practical relevance of theories can be enhanced, which is constantly questioned on many different grounds [e.g., 49; 50] – it is hoped that a TDA might increase the quality of scientifically guided practice, even if a full replacement of human decision making by strict application of such a theory will never be possible due to the complexity and unpredictability of practical situations – and which is also not desirable since practitioners should keep responsibility for their actions; indeed, not only the problematic issue itself needs to be considered (e.g., in the pandemic: health) but also additional conditions and possible side-effects which may belong to other domains (e.g., social, economic and political consequences of a lockdown).

However, such a TDA is likely to be confronted with the generality-concreteness antinomy [51, pp. 160ff.]: The more general a theory (e.g., a GT) is, the less concrete can it be. Generality in the sense of viability for many conditions requires that the theory abstracts from the particular circumstances, whereas the complexity of any given situation requires as concrete indications as possible; a general statement like *reducing CO_2 emission reduces the greenhouse effect* is viable all over the Earth, but is of little help when a concrete situation of CO_2 emission is at stake. One possibility is that in a TDA, generality can be achieved by the GT, concreteness by specific types of DT relating to particular cases. Further, concretization can be achieved in a process addressing the theory-practice transfer, as will be discussed in the next section.

3.3 TDA as action: Theory-practice transfer

As discussed in section 2.1, transdisciplinarity – and hence TDA – can be conceived not only as system of statements, but also as action. This applies particularly to the third issue, method. The challenges discussed in section 3.2 cannot be solved simply based on statements (section 3.1), but humans need to *do* something about it. To overcome the challenges against mankind, people – as individuals and as society – must act. Scientific insight is the best base to decide appropriate actions. However, the transfer from theory to practice is not trivial.

For this transfer, a *processual model* of how humans come to practical decisions by combining DTs and applying them to specific cases is proposed. In this concept, the GT from the TDA as system of statements is enhanced with a model of how to deal with the GT as well as with the respective DTs. This model is a shorter version of a model that has been provided repeatedly elsewhere [52, 53].

This model consists in several steps, from the construction of the scientific theories to the action. The steps in this simplified model are as follows (figure 2):

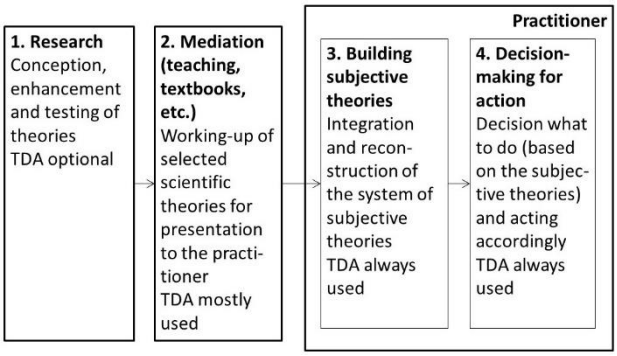

Figure 2: Model of the theory-practice transfer

(1) *Research* means providing scientific theories within the scientific community. These theories might be domain-specific (DTs) as researchers tend to remain within their domain; it is preferable, though, to provide TDAs in the sense of systems of statements (section 3.1).

(2) These scientific theories are usually destined for fellow researchers and not easily understandable for practitioners. In a second step, hence, these theories are transformed into statements that can be communicated to the practitioners; this step is called mediation [53]. Many types of communication channels can be used: teaching (e.g., university studies); textbooks; practical handbooks; prototypical examples; counseling; supervision; and the like. This working-up consists in selecting the scientific insights to be conveyed (it is impossible, for instance, to include everything that is known from research in the university studies, not to say in single textbooks). Given the complexity of the application situation – for instance addressing the challenges mentioned above –, restricting to a single domain is problematic. Most mediations, hence, apply TDAs. These TDAs might be similar to the researcher's ones, but usually they will include adaptations of several researcher TDAs and DTs and can hence be considered as some kind of super-TDAs.

(3) The practitioner perceives the messages from step 2. In a constructivist perspective, this means that he or she integrates the scientific theories into his or her system of subjective theories. This integration process consists either in a reconstruction of the scientific theories in a way that fits into the pre-existing concepts or subjective theories (assimilation [55]), or to change these concepts if assimilation is not possible (accommodation). Subjective theories consist in systems that can be interpreted as TDAs of their own. They have not yet been analyzed in terms of TDAs, but there is a high resemblance between the structures of subjective theories and of TDAs (figure 1); however, in contrast to scientific TDAs, they did not undergo a check for critical warranted assertibility but represent the practitioner's conviction with a strong confirmation bias, and they are implicit, not conscious, and not communicated. On the other side, our studies have shown that the subjective theories are much more complex than the scientific theories as distilled from the literature [54].

(4) Based on his or her interpretation of a given situation and on his or her practical goals in it, the practitioner

chooses elements from his or her system of subjective theories (the subjective TDA) on which he or she bases his or her decision how to act. This transfer from subjective theories to an action decision is not trivial; it is the topic of the so-called pedagogical tact which cannot be discussed here (see [53]). The decision how to act is followed by the act itself, which is a complex process in itself that cannot be discussed here either.

The theory-practice transfer is not so linear and unilateral as described here; rather, there are many feedback loops. For instance, the practitioners might come back to the mediator in teacher training, to inquire whether their dealing with the situation and their decision-making was appropriate and how successful the action was. Further, they learn from their successes (and failures). And finally, in research, the practical activities are evaluated. This shows that the presented model is a strong abstraction and that the processes within this model are much more complex than could be presented here. Nevertheless, it provides a good framework for further analyses.

The model can be used as a base for a prescriptive rational decision model, i.e., for a model to optimize processes of decision-making in complex situations. Researchers have provided explicit theoretical models for optimal decision-making [e.g., 56] which could be enhanced with the framework of TDA.

4. IS AND *OUGHT*

When dealing with challenges to mankind, the combination of *Is* and *Ought* is one of the most important TDAs, as overcoming these challenges always require factual knowledge (descriptive statements, *Is*) and the norm (prescriptive statements, *Ought*) to do something about it that is in conflict with other norms (e.g., economic requirements, personal interests, etc.). When deciding how to act, a person needs, on the one hand, a goal or a principle to follow, which need to be justified (*Ought*); on the other hand, he or she needs some knowledge (*Is*) of the features of the situation and of the possibilities to act to achieve what he or she thinks is required. *Is* and *Ought* can be interpreted as domains that need to be integrated in a TDA. First, the two domains are distinguished. Second, the need for such a TDA is discussed, based on the principle: Values without knowledge is blind, knowledge without values is unsocial. Finally, the *Is-Ought* TDA as action in the sense of the theory-practice transfer is analyzed.

4.1 The two domains

Is refers to factual knowledge, framed in descriptive statements like x is the case; if x, then y (with probability p); the more x, the more y; if I do x, y will result (with probability p); etc. *Ought* addresses normative issues in form of prescriptive statements: x is obligatory; x is prohibited; x is permitted (the three types are equivalent as each can be expressed by any of the other two). For the present purpose, evaluative statements are also included in *Ought*, like x is good, x is beautiful, etc. Although the prescriptive and the evaluative statements are different categories, they will be considered equal with respect to that both refer to values by saying that x has a certain value, whether in the sense of the obligation to achieve it (normative statement: someone *ought* to comply with or achieve the value) or in the sense of its quality (evaluative statement: something has a certain value). It would go beyond the scope of this paper to present an analysis of these relations; instead, I will simply distinguish *Is* (descriptive statements: facts) and *Ought* (prescriptive statements: values and norms). *Is* refers to what is known about something, so I will also call it knowledge, particularly in the context of education (knowledge acquisition as learning about facts) and of problem-solving (we need to know facts to be able to solve a problem); *Ought* refers to what someone should do and what is valuable, including their (ethical) justification.

Since David Hume [57, pp. 244f.], a meta-ethical standpoint that later would be called non-naturalistic or non-cognitivist has been an important principle to deal with *Is* and *Ought*. It consists in a strict separation of the two types of scientific statements, i.e., that one type cannot be justified by (reduced to, deduced from, or even logically related to, etc.) the other one [58]. Hence, according to this standpoint, *Is* and *Ought* are indeed separate domains based on scientific criteria.

This standpoint does not mean that either *Ought* or *Is* should be abandoned in scientific discourses, but they follow different logics [59]. Basically, descriptive statements are argued for on the grounds of observations, at least in principle: Not every phenomenon addressed in a descriptive statement is observable; however, it is not the factual observability that counts, but that the viability of a statement *could* be checked if an observation was feasible that was not biased. Prescriptive statements, on the other hand, cannot be justified through observation, not even in principle, but only through relating to superordinate prescriptive statements; in the logical argument (e.g., in a deduction from abstract norms to more concrete ones), descriptive statements will play a role, but the essence of the superordinary statement will always have to be prescriptive.

Beyond the *logical* arguments for Hume's thesis, I want to promote an *ethical* justification: The separation of *Is* and *Ought* is ethically justified because norms deserve a justification of their own: We need to discuss norms and not to delegate this discussion to any other instance, such as "other people defend this value as well". In other words, we, as a democratic society and as individuals, need to take responsibility with respect to the norms and values that we want to live, and hence justify these values.

Values are relevant only if they are in competition with other values, i.e., in situations where a person is in doubt whether to do x to satisfy some values v_x, but then to break some other values v_y, or to do y to achieve values v_y, but then to break the first values v_x; this is a (moral) dilemma. If there is no dilemma, there is no need to discuss about values. However, we are often not aware that in a given situation, there might be an alternative to doing x, and that this alternative (y) is related with another value (v_y). One issue within the domain of *Ought*, then, is the question

whether a person recognizes the possibility of an alternative action y and the value v_y related with it.

The need to consider *Is* and *Ought* simultaneously is justified because science as system of statements is not – and cannot be – values-free [60; 61; etc.] and scientists, in their actions, cannot avoid making values decisions because they must take responsibility for what they do. They ought also to report their values decisions in their publications for the sake of transparency; for instance, typically, a publication starts with some kind of (prescriptive) justification for the choice of the research topic, and it ends with a discussion section, which mostly includes values judgments related to the research topic and recommendations beyond the simple "further research is required" [62]. This is the more the case with respect to the challenges, as these affect all people, and the respective values must be taken into consideration when applying descriptive theories to solve them. Therefore, a TDA with the domains *Is* and *Ought* is indispensable.

To a dilemma given by a challenge, universally viable answers – both descriptive as well as normative – that would apply to every situation cannot be provided because of the complexity of the application situations and the generality-concreteness antinomy mentioned above (51, pp. 160ff.). Further, different stakeholders have different judgments about the priorities of the respective values under the given circumstances; taking all of them seriously, as far as their claims are justified, will lead to different solutions in different situations. In addition, scientific theories change constantly, and with every new development in scientific theories, the general rule about the relationship between *Is* and *Ought* would have to be conceived anew. Finally, the practitioners should keep their responsibility and autonomy, as said above. Therefore, again, one cannot use statements whose viability would be claimed once and for all and in all possible situations; rather, in a given situation, a procedure must be conceived that permits to deal adequately both with the descriptive and prescriptive statements in mutual relationship (as visible in the dilemmas with the alternative behaviors – *Is* – that comply with or break certain values – *Ought*). The theory-practice transfer model, as a TDA as action, is a possible approach to deal with that (section 4.3). The base is that it is the person's (or the democratic society's) responsibility to consider the different arguments and to get to a balanced conclusion. In education, then, the aim would be to promote both knowledge acquisition and valuing competence in the sense of the justification of values priorities with respect to as many issues as possible – or patterns of moral justification – for the individuals to enable them to deal responsibly with the challenges.

4.2 Values without knowledge is blind; knowledge without values is unsocial.

The justification – not only with respect to the challenges, but for actions in general – for conceiving a TDA with the domains *Is* and *Ought* can be based on the following principles: *Values (Ought) without knowledge (Is) is blind; knowledge without values is unsocial*.

Values without knowledge is blind: An Austrian finance minister recently said: We need some realism when deciding what to do, we cannot simply rely on idealism. In all societies there are idealistic people who fight for what they regard as to be the good cause. Our society needs such people. However, if an idealistic person does not know about the actual conditions for putting his or her values into practice, he or she will fail. Usually, these values are fairly general, and when it comes to putting them into action, the actual conditions will differ from situation to situation. This is the generality-concreteness antinomy discussed above: The values are not concrete enough to be directly turned into action in the specific situation. Rather, it is necessary to have knowledge about the current situation so that one can adapt one's actions – this corresponds to the deduction of concrete norms based on abstract (general) norms using descriptive statements, as briefly mentioned in section 4.1.

Knowledge without values is unsocial because the same knowledge can be used for good or bad purposes; the latter can only be avoided if individuals rely on values. Many of the challenges of mankind are caused by people who know how to maximize their own profit but do not care about the impact their deeds have on other people, on the environment, etc. In almost any challenge, we can say that human egotism plays an important role, from natural catastrophes (people take precautions against their consequences only after the event, although they could have predicted it – but such precautions are expensive) through man-made catastrophes (but avoiding climate change is costly) to direct negative impacts for the personal benefit, such as war, fraud, crime, or abuse. Knowledge is power (Francis Bacon quoted from [63]), and power can be (and indeed has been) abused for selfish purposes at the detriment of others if not controlled by other, more general values. Only a responsible use of power – which means using values to decide whether and how the power should be used – will attenuate the problems mentioned above.

In education, the *Ought*-domain is often neglected in favor of learning in the *Is*-domain. Large-scale assessments like TIMSS, PISA, PIRLS, etc., as well as meta-analyses about educational outcomes [e.g., 64] focus on knowledge acquisition (learning *Is*). The large-scale assessments that come closest to the analysis of how *Ought* is fostered in school, Civic Education, got far less attention in the scientific and education communities, not to say in the general public, than the ones focusing on *Is*: "Data-based findings in civic education are less readily understood and sometimes understood inaccurately by the public" [65, p. XI]. Teachers – particularly STEM-teachers – say that the curricular pressure (which focuses on *Is*) is much too important for them to permit values education (*Ought*), although most of them regard it as important and would like to do it as well [66]. And in publications on transdisciplinarity, values play no role or are mentioned casually [9] or considered "a new role" [67]; even if taking responsibility is mentioned as important disposition [68], this is not further analyzed although the relationship becomes obvious; only few publications address values explicitly [e.g., 6].

4.3 *Is* and *Ought* in the theory-practice transfer

The model of the theory-practice transfer presented in section 3.3 (TDA as action; figure 2) is an appropriate tool to address the roles of *Is* and *Ought* in practical decision-making based on scientific insights such as in teaching or when attempting to overcome challenges against humanity.

Transfers in these steps are not performed as copy-paste processes; instead, they include reduction and construction processes, i.e., information is selected, and further information is added to the statements that are started with in the respective steps. Both reduction and construction depend on normative judgments (*Ought*) even if they refer only to knowledge in the sense of *Is*.

(1) The *research* step includes descriptive (empirical) as well as prescriptive (ethical) theories. The latter are considered as scientific since they are discussed rationally in the sense of critical warranted assertibility (see above). Typically, researchers studying descriptive statements strictly separate these statements from the prescriptive ones, if they take the latter into account at all. However, as said above, researchers are responsible for their actions, whether they acknowledge it or not. This means that the descriptive researchers, whether consciously or not, practice TDA with respect to *Is* and *Ought*. (a) Since science is not values-free, the first issue of the TDA refers to how the individual researcher deals with his or her responsibility, which differs from person to person, from people who are very well aware of that [e.g., 69] to scientists who do their empirical studies without caring about their impact on the society and beyond. (b) The gathering of data and their analysis depend on the research question and methodological preferences, which are normatively guided. (c) Any publication of the research results contains only a selection of those that are actually available (reduction process), as well as the discussion section, which contains statements that go beyond the actual research results that are available (construction); these reductions and constructions are done based on values: What are the most important results in the present context? Which ones might be most beneficial for the society, for the progress of science, for promoting my own career? And what consequences can I conscientiously extrapolate from the results? (d) The reception of the research studies by fellow researchers is dependent on the latter's normative stance, including both reduction, as only a selection of the report's content can be perceived, and construction in form of their own interpretation of the reports.

(2) In the *mediation*, there will be necessarily a selection given the overwhelming number of research reports that is available on any given topic and the huge amount of information that is available in them. This selection is based on values judgments: What is more important, what can be neglected? Again, mostly, the choice and its (normative) justification are not made explicit. On the other hand, the selected research reports need interpretation, which is a (re-) construction process. And again, the TDA for the domains *Is* and *Ought* are performed by the person, in this case the mediator (teacher, textbook author, etc.).

(3) Both assimilation and accommodation are based on values judgments: What does the practitioner estimate as important, as valuable enough to take it into account in his or her system of subjective theories? Is he or she biased towards certain features of the proposed contents based on values? And in particular: Does the knowledge help him or her to achieve his or her goals? If not, he or she might likely not consider it any more. This process typically is not conscious, but comes about spontaneously, although one can imagine that it can be made conscious. This values-dependency of assimilation and accommodation is even more important with regards to the perception of normative theories, which often include pleas how to act. Hence, in this perception and integration, *Is* and *Ought* are combined by the practitioner, that is, a TDA is performed, with the GT being the practitioner's subjective judgment and how he or she handles implicit normative and descriptive statements. And indeed, the practitioners' subjective theories contain many prescriptive statements, many more than in scientific publications of empirical studies [54]. This is particularly visible in the frequent acceptance of fake news because these fit into one's values system. One must add, further, that the practitioner perceives the situation he or she is in in a similar way, with an important role of values consideration: Do the actual circumstances comply with my values judgments? Someone might perceive specific environmentally sensitive issues of the situation given his or her high esteem of the environment, whereas someone else values economic issues and does not perceive the environmental ones at all.

(4) Based on his or her interpretation of the situation (*Is*) and what he or she thinks should be changed (*Ought*), the practitioner chooses elements from his or her system of subjective theories (reduction) to capitalize on in decision-making, again considering *Is* (e.g., what can I do?) as well as *Ought* (what goal do I aim at?), and improvises (construction). The concept that addresses this transfer, the pedagogical tact, has always been conceived as a combination of *Is* and *Ought* [53].

The research and the experience show that in none of the steps, the non-naturalistic perspective is strictly handled. It is difficult, however, to make clear statements about that because in the discussions, very often, tacit assumptions about the *Ought* are made that enter implicitly the argumentation; it might well be that if such implicit arguments can be confirmed, the logic of the non-naturalist perspective erupts [70].

5 TDA HIERARCHIES

As shown above repeatedly, one can conceive systems of TDAs with super- and sub-TDAs, where the super-DTs that belong to the super-TDA become sub-TDAs with corresponding sub-DTs. This is illustrated in the bottom half of figure 3, which refers to the object theoretical level, i.e., the topic of interest (following figure 1) is a *phenomenon* (e.g., the pandemic). However, it is also possible to form TDAs on the meta-theoretical level (top half of figure 3),

which means that the topic of interest is a system of statements. This can form similar hierarchies as on the level of object theory. For this, for sake of simplicity, only TDAs as systems of statements (section 3.1) will be regarded; the corresponding analysis of the TDAs as action (section 3.3) would go beyond the scope of the present paper.

Meta level (statements about statements)	(1) Super-TDA							
	(1.1) Super-DT = Sub-TDA Domain of statements about *Theory*				(1.2) Super-DT = Sub-TDA Domain of statements about *Practice*			
	(1.1.1) Sub-DT e.g., generality-concreteness antinomy		(1.1.2) Sub-DT e.g., effect sizes		(1.2.1) Sub-DT e.g., need for concrete indications		(1.2.2) Sub-DT e.g., need for scientific statements about effectiveness	
	…	…	…	…	…	…	…	…
	Research topic: Statements, e.g., about the pandemic							
Object-theoretical level (statements about object)	(2) Super-TDA							
	(2.1) Super-DT = Sub-TDA Domain *Is*				(2.2) Super-DT = Sub-TDA Domain *Ought*			
	(2.1.1) Sub-DT e.g., medical issues of the pandemic		(2.1.2) Sub-DT e.g., economic issues of the pandemic		(2.2.1) Sub-DT e.g., health		(2.2.2) Sub-DT e.g., profit	
	…	…	…	…	…	…	…	…
	Research topic: object, e.g., the pandemic							

Figure 3: Hierarchies of TDAs on meta and object level

On the object theoretical level, the research topic in the sense of figure 1 is a phenomenon to be analyzed, for instance a challenge against humanity (in figure 3: the pandemic) and attempts to overcome it. A possible super-TDA (2 in the figure) deals with the two domains (which consequently are called super-DTs) *Is* (2.1) and *Ought* (2.2). Each of the super-DTs can be considered as a sub-TDA of its own, which has a set of sub-DTs. For *Is*, one can imagine a domain addressing the medical issues of the pandemic (2.1.1), like virus characteristics, contagiousness, vaccination, etc. Another domain (2.1.2) might be economic consequences of the pandemic, including economic decrease due to lockdown, unemployment, state intervention, etc. Further domains can be considered, like politics, social effects, etc. For *Ought*, different types of domains can be distinguished [42]; in the present case, the content of the values is addressed, for instance health (2.2.1) and profit (2.2.2). These prototypical values have been chosen to parallel the topics addressed in the *Is* domain: health as a value related to medical issues (but to be distinguished from them because of the non-naturalistic stance) and profit referring to values relevant in economy.
The meta level consists in statements about statements. The research topic, hence, is a set of statements, in the present example statements about the pandemic. The super-TDA (1) can address, for instance, domains like statements about theory (1.1) and statements about practice (1.2) – these two domains are important because overcoming challenges against humanity will require both scientific statements about the phenomenon (theory) and actions to overcome them (practice). Statements within the sub-TDA *theories* can deal, for instance, with the domains of generality-concreteness antinomy (1.1.1) which has been addressed repeatedly above: This domain is about the scope within which a given statement is viable, depending on its concreteness: the more general, the less concrete. A second sub-DT (1.1.2) might be the effect size of statements, i.e., how strong the impact of the independent variable (if-component) is on the dependent variable (then-component): In natural science, this effect size is much higher than in the social sciences, where it is often disappointingly low [48], as already mentioned above. On the side of the sub-TDA *statements about practice* (1.2), sub-DTs can state that practitioners need concrete recommendations how to act in a given situation (1.2.1) and that they need scientific statements that inform about effectiveness of possible interventions (1.2.2). As on the object-theoretical level, the examples have been chosen to correspond: The concreteness requirement in practice (1.2.1) is confronted with the lack of concreteness of generalizable theoretical statements (1.1.1), and the practitioners' need for information about effective interventions (1.2.2) has its corollary in the effect size (1.1.2), which when low might jeopardize the intervention.
The hierarchical system can be extended, as sub-DTs (1.1.1 to 1.2.2 and 2.1.1 to 2.2.2, respectively) can form sub-sub-TDAs. It must be emphasized, however, that although many such iterations could be imagined, there are limits with respect to the information that can be handled by the researchers. It might be advisable to practice a TDA as action by involving researchers from different domains or with different backgrounds (see at the beginning of section 2: people). On the other side, one can interpret figure 3 as a super-super-TDA with the domains object-theory and meta-level – this might be an interesting further analysis that cannot be performed here.

6. CONCLUSIONS

The above analyses in general (sections 1 to 3), with specific application to the *Is-Ought* TDA (section 4), and with respect to hierarchies of TDAs (section 5) show that dealing with TDA is not trivial. The first issue is the definition of the domains. It is important to be aware that usually the domains at stake depend on the topic of research. The *Is-*

Ought TDA, however, demonstrates that there are cases of obvious domain distinction, if one follows the Humean principle of non-naturalism, i.e., the strict separation of *Is* and *Ought*. But not all people agree with this separation; in this case, one can still assume *Is* and *Ought* as different domains, but this needs to be argued: The two domains are certainly distinct, but if not the Humean principle, what are the exact differences? Similarly, the distinction of theory and practice (on the meta-level) is a traditional distinction that requires a relation to be established, which can be done through a TDA.

In most cases, however, the domains to be taken into account by the TDA will depend on the research question and the researcher's theoretical preference. In this case, it is necessary to make clear in what regard the domains are different. For instance, one will have to ask whether the differences are on the level of the theory; this is the easiest case, as the DTs as well as the GT can be theories. On the other hand, it might well be that a TDA is sought with domains that differ in their epistemological background. In such cases, it is necessary, (1) to accept that there are several epistemological approaches that can be considered – this is not self-evident, as the representatives of different approaches tend to fight each other. (2) Some understanding of the respective approaches is required, which is not distorted by biases or even ideologies against one or the other approach. (3) The communalities of the approaches with respect to the topic of research must be recognized. This can consist, for instance, in the empirical observations provided by the different approaches, but in this case, biases due to the assessment methods (which will differ in the different approaches) must be taken into account. (4) Based on the communalities, a GT is established.

How is the GT conceived? As argued above, this can be conceived either as theory or as action model (TDA as action) with a procedure accomplished by the different protagonists of the TDA. Whether additional forms of TDAs (beyond systems of statements and actions) can be imagined remains to be seen.

For a given research question very different TDAs can be conceived; in the above discussions, the proposed TDAs are just one possibility, but one can imagine other TDAs as well. This is in contrast to the goal of transdisciplinarity that is sometimes evoked to be the unification of science concerned with humans or unity of worldviews [1]. Such an overarching goal is unattainable even in rudiments because the world is too complex for such an ambition, not the least reason for this being the generality-concreteness antinomy repeatedly mentioned above, since the situation-specific concretization of general statements causes special problems whose solution seem not foreseeable. Such an aim would also be in contradiction to the constructivist conception and the replacement of truth by viability [13] which is at the base of the TDA concept presented above. An approach that addresses the specific research issues and challenges to humanity without neglecting the relevant other issues but without, on the other hand, trying to handle issues that are only remotely linked to the problem, if at all, seems more appropriate; such issues might eventually turn out to be relevant and can then be integrated into a new TDA that builds on the previous one.

The concept of TDA cannot be considered as an algorithm to be applied the same way for every research question. Rather, it might require some creativity to find a viable TDA. But in any case, the choice of specific domains and the corresponding DTs and the neglect of others, and the conception of a GT – and hence the formulation of a TDA – need to be argued for on scientific grounds.

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