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Futures 38 (2006) 1046–1059
FUTURES
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Transdisciplinary research: characteristics, quandaries and quality

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Available online 18 April 2006

Abstract

There is a shifting landscape for knowledge generation in contemporary societies that suggests a bright future for transdisciplinary (TD) research. Interestingly, however, there is currently no clear consensus on what transdisciplinarity is or how its quality can be evaluated. This paper uses three avenues to advance and clarify our understanding of transdisciplinarity. Firstly, we survey the theoretical literature and identify key characteristics used by authors in the field to distinguish transdisciplinarity from related research approaches. These characteristics are problem focus, evolving methodology and collaboration. In our discussion of these we highlight variations in description that have significance for practice. Secondly, we explore three interesting quandaries that transdisciplinary researchers face (integration, reflection and paradox) discussing how these quandaries manifest in different dimensions and their potential as both challenge and opportunity for practice. Finally, we use our synthesised characteristics and challenges to shape two alternative frameworks for evaluating the quality of TD endeavours. Our first framework is based on strategic questioning and is potentially useful to individuals seeking to improve the quality of their work. Our second framework adapts an existing quality schema to the unique challenges of transdisciplinarity and may be more appealing to those seeking to compare TD research projects.

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doi:10.1016/j.futures.2006.02.011

1. Introduction

A convergence of inter-related economic, environmental and social drivers is shifting the landscape within which university-based knowledge generation takes place [1–3]. In the economic sphere, an increasing emphasis on the development of knowledge economies is promoting the generation of knowledge aimed at solving consequential problems[1] [4]. From an environmental perspective, the need for sustainability is underpinning a growing demand for research that takes account of complex contexts and interactions between natural and social systems [4,5]. In the social context, calls for interaction with an increasingly engaged populace [1,6,7] are driving research in more participatory, consultative and deliberate directions [5,8]. Taken together, these drivers indicate a changing research landscape promoting knowledge production that attempts to solve real-world problems through a "context specific negotiation of knowledge" [9].

This shifting landscape calls for the development and broader application of research practices that differ from the "generalising, decontextualising and reductionist" approach that has traditionally characterised disciplinary approaches to knowledge generation [4]. Problem focussed, contextualised and consultative research is seen by many knowledge analysts as incompatible with the disciplinary framing of research problems and the institutional structures and processes that support, regulate and promote disciplinarity. A supplementary approach that is advanced as an appropriate response to the shifting mandate faced by university-based researchers is that of 'transdisciplinarity'.

While research that transcends disciplinary boundaries has long been undertaken in the margins of the tertiary research environment, the past 15 years has seen substantial attention devoted to 'transdisciplinarity' with concerted efforts to theorise this approach and distinguish it from more familiar research practices (eg. disciplinary, multi- and inter-disciplinary research) [10,11]. Some examples of this increased attention include two recent international conferences that shed light on the intentions of transdisciplinary (TD) research and some of the institutional and structural barriers that limit its uptake within the tertiary research sector [10,12]. These conferences also provided rich accounts of specific transdisciplinary research projects. The increased attention awarded transdisciplinarity was also evidenced in 2004 when the journal *Futures* devoted a special edition to the discussion of theories of transdisciplinarity and the provision of examples of its application in practice. Each of these forums speaks of the ascendency of transdisciplinarity and of the perceived need for the development of discourses and communities of practice around what is still a fledgling[2] approach to research.

Efforts at theorising transdisciplinarity are significant in that they offer the potential to define and recognise this approach to research as distinct from the more accustomed cross-disciplinary approaches of multi- and interdisciplinarity. Theorising transdisciplinarity also creates the opportunity to name and discuss processes and outcomes unique to this approach, and to address an acknowledged barrier to the diffusion of TD practice—the lack of critically robust means for judging what 'good' TD research might look like [10,12]. What we find particularly interesting in these recent theory building efforts is the variation

[1] By consequential, we mean problems that originate in the broader community, tend to be immediate or pressing and have current or potential impacts on broader society and the environment.

[2] We use the term 'fledgling' to compare transdisciplinarity with more established approaches to research that enjoy established supporting institutional structures, communities of practice and processes of evaluation.

in, and potential conflict between, the distinguishing characteristics of transdisciplinarity that are foregrounded or favoured by different theorists.

In this paper we begin by exploring some of this theoretical variation in the distinguishing characteristics of transdisciplinarity. Our exploration of this variation provides the raw materials for the synthesis of coherent means for distinguishing transdisciplinarity from multi- and interdisciplinary approaches. Following our synthesis of distinguishing characteristics, we identify some significant theoretical challenges and conceptual quandaries that are both explicit and implicit within the literature on TD research. Our discussion of distinguishing characteristics and significant challenges has the potential to inform the practice of both existing and neophyte TD researchers. Perhaps more significantly, the characteristics and challenges we synthesise offer a fertile starting point for the development of critically robust means to discuss and evaluate the quality of transdisciplinary research.

The three interrelated aims of this paper are to:

1. Develop a description of TD research that while sensitive to subtle variations, captures the areas of broad agreement on what distinguishes this approach from its more familiar forebears (eg. disciplinary, multidisciplinary (MD) and interdisciplinary (ID) research).
2. Identify and explore some challenges and quandaries that are either explicit or implicit in TD theory.
3. Contribute to the development of frameworks for evaluating the quality of TD research.

2. Distinguishing transdisciplinarity

Having surveyed the theoretical landscape on transdisciplinarity, we identify three key characteristics that have been used by authors in this field to describe what constitutes a TD approach to research as distinct from multi- and interdisciplinary approaches. These characteristics are problem focus, evolving methodology and collaboration.

2.1. Problem focus

One of the broadly agreed characteristics of transdisciplinary research is that it is performed with the explicit intent to solve problems that are complex and multi-dimensional, particularly problems (such as those related to sustainability) that involve an interface of human and natural systems [1,9,13–16]. The founding idea here is that society is facing problems manifest in the real world that are complex, multi-dimensional and not confined by the boundaries of a single disciplinary framework. TD research is then characterised by its willingness to engage with these types of societal problems.

TD research therefore starts with a problem that is 'in the world and actual' as opposed to 'in my head and conceptual'. This description does not deny the more conceptual, philosophical and theoretical dimensions of the problems approached by TD research, it simply means that these philosophical or theoretical dimensions are not the starting point for framing the subject of TD research. Rather, the research problems that become the focus of TD approaches come to attention and are framed as a function of their manifestation in 'the world' as we experience it (i.e. in society, in the environment).

One of the implicit implications of this understanding that a focus on 'real-world' problems characterises TD research is the notion of creating change. In focussing on problems that exist in society, the researcher aims to contribute to their solution. The contribution of research to the solution of these problems will not be answers to conceptual puzzles, but rather, practical outcomes that can be applied in a social or environmental context and which will therefore bring about some degree of change in those contexts. This inherent feature of 'creating change' highlights the relevance of using the term 'consequential' to characterise TD research approaches and problems.

For those authors who foreground the issue of consequential problems as a distinguishing character of TD research, the question remains as to what MD and ID research are focussed on if it is not real-world problems. Both Balsiger [13] and Gibbons and others [1] characterise MD research as being organised around a theme rather than a problem. Balsiger [13] explicitly states that 'multidisciplinarity has no intention of problem-solving. It is thematically oriented…several research programs are only contributing to a given theme from a clearly disciplinary perspective'. In other words, MD research approaches allow for the provision of different perspectives on a given theme (e.g. unemployment) but the intent is not to provide a 'solution'. For Balsiger [13], MD research provides a range of disciplinary perspectives on a given theme, but it is the recipient of this research who holds responsibility for deciding how to use these different perspectives in framing the specific problem and arriving at a solution. While Balsiger [13] does state that ID research can be focussed on a problem, he suggests that it is the question of who is involved in the collaborative project that distinguishes interdisciplinarity from transdisciplinarity (for more on this see Section 2.3 on collaboration).

While a problem focus is a broadly agreed feature of TD research, not all authors writing on transdisciplinarity see this as an exclusive or defining trait. Dissenting authors do not support the idea that MD research is thematically rather than problem oriented. For example, Hammer and Soderqvist [15] describe MD, ID and TD research as all being problem focussed. When the idea of a problem focus is not limited to TD research, we find a foregrounding of other characteristics as the distinguishing features of transdisciplinarity.

2.2. Evolving methodology

There is broad agreement in the literature that there can be no single prescribed methodology for TD research. Authors agree that the methodologies employed in TD research need to respond to and reflect the problem and context under investigation. A number of theorists do however highlight the issue of methodology in their efforts to distinguish MD, ID and TD approaches to research.

In terms of the methodological approach that characterises MD research, we find broad agreement in the literature that this type of research tends to retain disciplinary autonomy. Bruce and others [17] suggest that in MD research "each discipline works in a self contained manner" and Horlick-Jones and Sime [4], hold that MD research relies on distinct discipline-based methodologies. Ramadier [18] reiterates this idea by suggesting that MD research involves "the juxtaposition of theoretical models belonging to different disciplines". These descriptions suggest multidisciplinarity is characterised by the unintegrated application of more than one disciplinary methodology.

When it comes to describing ID research, the general sense is that this approach to research involves the development of a shared methodological approach across different disciplinary frameworks. For example, Lawrence [19] suggests that ID research involves mixing disciplines and Ramadier [18] holds that it "constructs a common model for the disciplines involved". Hammer and Soderqvist [15] state that ID research involves agreeing on a methodological approach while Gibbons and others [1] succinctly state that interdisciplinarity is characterised by "a common methodology—working on different themes but within a common framework that is shared by the disciplines involved". These quotations indicate that ID research is characterised by the development of a shared problem formulation and a common methodological framework for the investigation of different themes or aspects of the research problem.

In contrast to multi- and interdisciplinarity, transdisciplinarity is characterised by an interpenetration of epistemologies in the development of methodology. Authors who describe transdisciplinarity suggest that the dissolution of disciplinary boundaries is necessary for the construction of novel or unique methodologies tailored to the problem and its context. The description of transdisciplinarity provided by Horlick-Jones and Sime [4] develops this idea. These authors initially state that in TD research "elements of methodologies drawn from different disciplines are combined within a single approach-…an evolved methodology". This seems to echo the types of definitions given above for the approach to methodology that characterises ID research. However, Horlick-Jones and Sime [4] develop their thesis by highlighting the importance of an integration of epistemologies for transdisciplinarity. The integration of different epistemologies is also emphasised by Gibbons and others [1]—"Transdisciplinarity arises only if research is based upon a common theoretical understanding and must be accompanied by a mutual interpenetration of disciplinary epistemologies".

What we see emerging then is the idea that MD research involves disciplines investigating research themes using their own methodological approaches. ID research involves developing a common framework within which distinct epistemological approaches are used to investigate different themes or aspects of a research problem. While in contrast, a TD approach calls for development of methodology that involves an interpenetration or integration of different disciplinary methodologies and, ideally, epistemologies. Lawrence [19] calls this a 'fusion' (as opposed to a mixing) of disciplines.

A subtle but significant variation on this idea of transdisciplinarity as fusion of disciplinary methodology and epistemology is presented by Balsiger [13] who refers to the work of Feyerabend, and talks about the need for scientists to refuse methodological reductionism and adopt a pluralistic methodology. He interprets this as legitimating a TD approach. The term "pluralistic methodology" does not necessarily contradict the idea that transdisciplinarity involves the 'fusion' or interpenetration of methodologies as described above. This contradiction would only apply if "pluralistic methodology" is interpreted as involving the application of an unintegrated plurality of methodologies. If however, we see it as a process that involves integrating plural methodologies, or exposing a methodological approach to a plurality of alternative ideas and views as a means to developing a common approach, then Balsiger's [13] call for pluralistic methodology would be consistent with the characterisation of TD methodology given above. Characterising TD research by the process of having multiple research approaches critiquing and deconstructing one another to develop an evolved methodology resonates with Ramadier's [18] concept of "collaborative deconstruction".

While we have argued that there is a pattern in the theoretical literature on transdisciplinarity that emphasises the importance of developing an evolved methodology, interesting questions remain about whether methodology and the research process develop in a linear or iterative fashion. The idea of an 'evolved' methodology as presented above implies that once developed, methodologies for TD research are complete and remain static throughout the research process. Alternatively, we suggest that an important characteristic feature of TD methodology is the way in which it continues to evolve in an iterative relationship with the research. Such a methodology continues to develop over the course of the project in response to the research context and the learning and changing perspectives of stakeholders in the research. The implication of this is that TD researchers go beyond a linear application of a static methodology and aim for an evolving, dynamic, or responsive methodology that is iterative and an ongoing part of the research process. This apparent subtle difference between evolved and evolving methodology has significant implications for how TD research is performed in practice.

2.3. Collaboration

If TD research is focussed on complex and multidimensional problems and involves the development of a shared and evolving methodology that has fused different disciplinary approaches, the importance of collaboration becomes obvious. While MD and ID research will also involve some degree of collaboration, the issue of how collaboration is managed and who is involved in this process is used by some theorists to distinguish transdisciplinarity from other cross-disciplinary reserach approaches.

Some theorists distinguish transdisciplinarity as collaborative knowledge generation between researchers and stakeholders. For example, Balsiger [13] has stated that if collaboration only occurs between different scientific disciplines then this would be an example of an ID research project. On the other hand, if collaboration is broadened to include consideration of the experiences of those people affected by the research, then this would be an example of transdisciplinarity. Thompson-Klein [16] extends the notion of collaboration beyond shared knowledge generation and suggests that the most important difference between ID and TD research is that transdisciplinarity includes the "intentional involvement of stakeholders in the definition of problems and those criteria, objectives and resources used to analyse and resolve them". Horlick-Jones and Sime [4] justify the need for this collaboration with the broader community by saying that "engaging with spheres of practice and experience, and associated informal knowledges, provides access to both the real-world character of human reasoning and interaction, and with the affording and constraining nature of social and material contexts". In other words, collaboration provides a type of 'reality check' for research processes and outcomes. What we see emerging then is the idea that collaboration with stakeholders and the broader community is an important characteristic of TD research practices.

The foregrounding of collaboration as a distinguishing feature of transdisciplinarity raises the question as to whether it is possible for a lone researcher to undertake TD research. Emphasising the importance of collaboration for TD research would seem to imply that the research requires a group of individuals from a range of different disciplines to come together to conduct research, precluding individuals from researching in a TD manner. If however, we see the distinguishing feature of transdisciplinarity as not simply collaboration between researchers from different disciplines, but as collaboration with the

community, then this allows the possibility for lone researchers to adopt TD approaches. What becomes important then is the ability of the individual to fuse knowledge from a number of different disciplines and engage with stakeholders in the process of generating knowledge. Individuals undertaking TD research could be discipline-based researchers who have simply chosen to adopt TD approaches for a particular project, or they could be researchers who have specifically adopted TD approaches as their primary modus operandi. We contend that having researchers who regularly operate in a TD manner would foster the development of the unique integrative and collaborative skills required in TD research. These TD researchers would then have the potential to act as catalysts, instigating and facilitating TD research across a range of disciplinary and institutional contexts and building bridges between disciplines, researchers and communities.

In this section then we have reviewed how authors in the field define and distinguish transdisciplinarity from the more familiar multi- and interdisciplinary approaches to research. We identified the three key themes of problem focus, evolving methodology and collaboration as potentially useful raw materials for the development of coherent means to distinguish TD from other approaches to research. Within each of these distinguishing themes, we highlighted variation with highly significant implications for how transdisciplinarity is practiced. To develop a coherent framework that is capable of both distinguishing transdisciplinarity and fostering its practice, it is important that these areas of significant variation become a focal topic for further theoretical discussions and debates. Transdisciplinarity also faces some important practical and conceptual quandaries with significant implications for practice and these also warrant further attention.

3. Challenges and quandaries of transdisciplinarity

While the preceding section reviewed how transdisciplinarity has been variously defined in the literature, in this section we further develop the concept of transdisciplinarity by presenting some of its important challenges and conceptual quandaries. The specific challenges and quandaries we discuss are those associated with integration, reflection and paradox. These quandaries are worth exploring because, just like the distinguishing characteristics, they have real implications for the way that researchers might choose to practice transdisciplinarity. Rather than providing a prescriptive account of how TD researchers should address these challenges, our discussion here is primarily aimed at highlighting these important conceptual quandaries so as to encourage TD researchers to explicitly consider the implications of these for their research and develop their own responses to them. Rather than obstacles, we view these quandaries as exciting new challenges for the TD research community.

3.1. Integration

TD research offers the potential for many different dimensions/scales of integration. Each of these scales of integration pose unique conceptual and practical challenges for TD researchers [10]. The three dimensions of integration we discuss in this section relate to integrating epistemologies, theory and practice, and the researcher and their research context.

On one level, TD researchers are required to integrate knowledge from different disciplines. In doing this across the natural and social sciences there is also a particularly

obvious need to integrate different epistemologies. Some theorists of transdisciplinarity have developed concepts to help tame some of the challenges involved with this integrative exercise. For example, Ramadier [18] talks about the need to move away from a search for a unity of knowledge towards a search for coherence. Julie Thompson Klein [16] draws attention to the way in which Nicolescu calls transdisciplinarity "the science and art of discovering ridges between different areas of knowledge and different beings". Henagulph [20] cites the ideas of Morin to suggest that we need to focus on finding and developing "knots of communication". What these ideas suggest is that in trying to integrate different knowledges and epistemologies, the TD researcher does not need to aim towards the development of a single unified 'truth' but rather, can seek to integrate the different knowledges by looking for coherence, correspondences and 'ridges' across the differences, generating knowledge by finding, identifying and communicating patterns across diverse disciplines and discourses.

For those who draw a distinction between theory and practice, drawing these research elements together represents another dimension of the integrative challenge of TD research. We call this dimension of integration 'TD praxis' [21]. While theory and practice might be conceptualised as separate bodies of knowledge which the researcher 'visits' iteratively, the aim of TD praxis would be for the bodies of theoretical and practical knowledge that the researcher engages with to inform each other. In this way, the researcher has the opportunity to remake/reinterpret theory through insights gained in practice and vice a versa: a process known as 'praxis'. Praxis is defined in Fawcett, Bell and Russell [22] as the idea that theory and practice are related, in that theory should be grounded in practice and practice enriched by theory. We take this a little further and suggest that, in 'TD praxis', the two should co-evolve to a point where they are integrated and/or resonant. How this process proceeds in practice is one of the integrative challenges for transdisciplinary researchers.

The third dimension of integration builds on the idea of TD praxis and relates to the notion of being an embedded or engaged researcher. This scale of integration suggests that the researcher develops a richer understanding of the problem if they are actually engaged with it. Rather than simply being an outside observer, being an embedded or engaged researcher means that issues of practice are in some sense directly experienced by the researcher. The idea here is that the TD researcher develops a deeper understanding of the problem they are investigating if they can manage to not only fuse different theoretical and lay knowledges, but also engage with the problem in context directly and experience the practice first hand as an embedded researcher. An inherent challenge associated with this dimension of integration is how to maintain some critical distance while working as an embedded researcher. One avenue for working with these potentially conflicting agendas would be to nurture reflective research habits.

3.2. *Reflection*

Having suggested that TD researchers benefit from being engaged with the problem they are investigating, it subsequently becomes imperative to highlight the importance of reflection for TD research processes. When researchers become engaged in the problem they are investigating assumptions of objectivity will inevitably come into question. This means that it becomes important for the researcher to reflect on how their own frames of reference/values/beliefs/assumptions etc have shaped the conceptualisation of the problem,

as well as the development of the method of investigation and the solution. Again, exactly how this reflective process proceeds and the way in which it influences the research outcomes is a challenge that TD researchers will need to consider.

Another dimension of reflection required in TD research is that of using different bodies of knowledge and their methodological approaches to critically reflect on one another in a transformative process. In contrast to the process of personal reflection described above, this dimension of reflection can be viewed as a more communal in form because rather than reflecting on how individual frames of reference influence research practice, it is a process whereby different bodies of knowledge are considered comparatively to uncover the underlying values and assumptions incorporated in each. Rather than simply combining a body of knowledge A with that of B, this dimension of reflective practice suggests that in TD research it is important to consider A in light of B and vice versa, and importantly, to have this process, to some extent, transform, reshape or reflexively articulate these bodies of knowledge for their specific application in the research project at hand. Rather than simply accepting a body of knowledge as 'fact' and applying it to a research problem, this dimension of reflection requires TD researchers to deconstruct and rebuild bodies of knowledge through exposure to one another. This more communal dimension of reflection will perhaps be most important during the process of developing a TD research methodology.

3.3. Paradox

In trying to integrate different knowledges and epistemologies, as well as theory and practice, the TD researcher will inevitably face the problem of paradox. While some might see the presence of unresolved paradoxes as evidence of poor quality TD outcomes, others may view the accommodation of dilemma as a necessary (perhaps unavoidable) feature of TD research processes. The challenge of how TD researchers approach or deal with this issue of paradoxes is an area that would certainly benefit from continued thought and attention.

One suggestion that has emerged in the theoretical literature is the notion of understanding paradoxes as relating to different levels of reality [20]. For example, while one body of knowledge might be useful for explaining or comprehending the behaviour of atoms, a different and paradoxical body of knowledge might be needed to explain the sub-atomic world because this represents a different level of reality[3]. For Henagulph [20], this notion of different levels of reality offers a way out of the binary logic that dominates modern Western thought and the problem of the paradox that it creates. Instead of an either/or approach to understanding the nature of reality, the idea of different levels of reality and the "logic of the included middle" enables us to conceptualise a way in which something can be both A and non-A. Henagulph [20] highlights that this is not a new conceptualisation as many cultures and philosophies (e.g. the belief systems of Celts, Native Amercians and Taoism) accept the inseparability of dualities. The idea that there are different levels of reality which act according to fundamentally different laws is a conceptualisation that enables the TD researcher to accept and accommodate complexity and the presence of paradox.

Thomas Mann has been quoted as suggesting that "A great truth is a truth whose opposite is also a great truth" [23]. This quotation can perhaps be seen to represent a useful

[3]Henagulph [20] highlights the distinction between levels of organisation and levels of reality by suggesting that the same laws can apply to different levels of organisation while different levels of reality will follow fundamentally different laws.

statement for meditation (or koan[4]) for the TD researcher struggling with the problem of paradox. The utility of meditation on paradox is that it fosters the development of creative and innovative mindsets. For example, while Mann's statement is a paradox, when viewed in light of a creative conceptual development such as levels of reality, the apparent contradiction becomes comprehensible. Further meditations on such phrases could potentially lead to the development of additional useful insights for TD researchers handling challenges associated with the presence of paradox. It is worth emphasising that the problem of the paradox and the conceptual creativity it requires might encourage TD researchers to employ both logic and intuition in their research approaches.

In this section we have identified and discussed three key challenges for TD researchers: the different dimensions of integration required, the potential for two levels of reflection and the creative conceptual developments demanded by the presence of paradox. While our primary aim in this section has been to encourage TD researchers to recognise these challenges and explicitly consider how they will be negotiated in the research, our discussion of these challenges can also be used to inform the development of frameworks for evaluating the quality of TD endeavours.

4. Evaluating the quality of transdisciplinarity

The evaluation of the quality of disciplinary research is traditionally performed by peer review. This relies on the existence of an established community of peers who judge research using quality criteria that are often implicit in disciplinary knowledge frameworks. As transdisciplinarity is a nascent approach to research, there is not yet a well-established community of peers experienced in reviewing the quality of TD endeavours. This means that more formal approaches to quality evaluation may be required. Additionally, because TD research is broad, diffuse, evolving and context specific, the criteria for quality assessment will arguably be implicit in the research context rather than in particular disciplinary frameworks. The lack of an established peer community and the contextualised nature of TD research mean that critically robust ways to discuss and evaluate the quality of TD research are underdeveloped and insufficient. This insufficiency has been acknowledged by key theorists in the field [10,12]. We view our synthesis of characteristics and challenges (presented in Sections 2 and 3), as useful raw materials for developing discourses, frameworks and tools for the evaluation of TD research quality. One way this raw material might be utilised is in the development of a series of strategic [24] or reflective [25] questions that evaluators might ask of individual research projects.

Evaluators of quality could ask how well the characteristic features (problem focus, evolving methodology, collaboration) and challenges (integration, reflection, paradox) of transdisciplinarity have been accounted for. For example:

- How was the research problem formulated?
- What is the relationship between methodology and problem context? How have competing epistemologies been reconciled?
- How has collaboration featured in the project?

[4]A koan is a teaching tool used by Zen Buddhists and it is usually a puzzling and often paradoxical statement or story that is to be meditated on as a means of gaining enlightenment and developing intuitive as opposed to logical/rational thinking.

- How well have knots of communication between different bodies of knowledge been created? Is the weave informative, useful, compelling?
- Does the research acknowledge, resolve and/or accommodate paradox?
- How has the researcher reflected on, recognised or accounted for the limitations and subjectivities of their approach and project outcomes?

A second approach to evaluating TD research might be to use the synthesised characteristics and challenges to reinterpret an established approach to quality assessment. One such established approach is that developed by Glassick and others at the Carnegie Foundation [26]. This schema for evaluating the quality of scholarship has been adopted by a number of universities because it offers a formal yet flexible process for evaluating academic endeavour. According to this schema, the work of academics can be evaluated using the following six criteria:

1. Clear goals—the scholar identifies important questions in the field, clearly articulates the purpose of the work and defines realistic objectives.
2. Adequate preparation—the scholar demonstrates an understanding of existing knowledge in the field and brings the necessary skills and resources to the project.
3. Appropriate method—the scholar selects and effectively applies methods appropriate to the goals and modifies these methods in response to changing circumstances.
4. Significant results—the scholar achieves set goals, makes an important contribution to the field and highlights new areas for exploration.
5. Effective presentation—the scholar employs appropriate means (style, medium, forums etc) to clearly communicate the work to its intended audience.
6. Reflective critique—the scholar uses a breadth of evidence to critically evaluate their work and through this process improves the quality of future endeavours.

As originally formulated, this schema was purposefully generic, designed to evaluate a range of scholarly activities. To tailor this schema to the evaluation of TD research, the characteristics and challenges we have synthesised in this paper could be used to refine and reinterpret these established six criteria. In reinterpreting this schema, our aim is to supplement rather than supplant the six criteria to make them specifically relevant for transdisciplinarity. In presenting these criteria, we are not suggesting that TD researchers have to satisfy them all equally to produce work of quality. What is important, however, is a demonstrated appreciation for the significance to practice of the issues highlighted by these criteria.

For example:

1. Responsive goals—in TD research, the scholar defines goals through ongoing consultation with the problem context and stakeholders. Goals may therefore not be clear from the outset and may shift in response to developments over the course of the project.
2. Broad preparation—in TD research, 'adequate preparation' would require accessing and integrating literature and theory across a broad range of disciplines, as well as engaging with the problem in its broader context.
3. Evolving methodology—an 'appropriate method' for TD research is ideally epistemologically integrative and capable of evolving in response to a changing research context.
4. Significant outcome—the outcome of TD research should contribute to the solution of a

manifest problem in a way that is capable of satisfying multiple agendas, for example, be concurrently socially robust, environmentally sustainable and economically viable.
5. Effective communication—in support of collaborative processes, TD research should initiate and maintain two way communication with stakeholders over the life of the project.
6. Communal reflection—in addition to personal reflection, TD research should include a more communal reflective process—multiple disciplinary and stakeholder perspectives informing and transforming each other throughout the life of the project.

The two approaches to quality assessment we have articulated here could inform two different scales of TD evaluation. The first approach of strategic questioning would be well suited to individual researchers seeking to understand and iteratively improve the quality of their work. Such researchers could choose to adopt and expand on questions like those we listed above to create a quality improvement process that is tailored to their professional development needs. The second approach may be more appealing to institutions or individuals that need to compare TD research projects. For example, funding institutions may be required to compare and rank competing transdisciplinary projects according to their merit. This process could be assisted by the further development of standardised yet flexible evaluative tools like the one we have begun to synthesise here.

5. Conclusion

The shifting context of knowledge generation in contemporary societies is leading to increased theoretical attention being directed at transdisciplinarity as an appropriate response. In this paper we have reviewed the emerging theoretical literature on transdisciplinarity and identified the three key themes of problem focus, evolving methodology and collaboration as characteristics used to distinguish this approach to research from other cross-disciplinary approaches. Through this, we have highlighted areas of broad agreement and flagged some subtle variations with potentially significant implications for research practice. We have also presented a descriptive account of some of the explicit and implicit conceptual quandaries and challenges facing TD researchers, namely, those associated with integration, reflection and paradox, which also have the potential to significantly impact on the way in which TD research is undertaken. Finally, we have used this synthesis of characteristics and challenges to consider how to assess what constitutes 'good' TD research and have provided evaluative tools for quality assessment specific to transdisciplinarity.

Our aim in this paper has been to develop a coherent framework for understanding transdisciplinarity, including what distinguishes it from other cross-disciplinary research approaches, what challenges await researchers adopting this approach and how the quality of these endeavours can be evaluated. If transdisciplinarity as a research approach is to respond to the demands of the shifting context for knowledge generation, theorising efforts aimed at demarcating this approach and addressing its associated challenges (including quality assessment) will need to continue. It is also vital that these theorising efforts be enriched through iteration with practice. It is our hope that in synthesising TD theory, highlighting areas where further attention is desirable and contributing new insights and suggestions, this paper has offered clarification on this emerging approach to research and the exciting opportunities and challenges it offers the research community.

Acknowledgements

This research was funded in part by the Educational Strategic Development Fund at the University of Wollongong. We extend our thanks to Jasmin Sydee for review and critical comment on an early draft of this manuscript.

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