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A rose by any other name? Transdisciplinarity in the context of UK research policy

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Abstract

This paper assesses developments in transdisciplinary research in the UK. While we support the thesis that transdisciplinarity is still not mainstream and is rarely supported *per se* by funders of research, this paper examines the extent to which UK research policy has embraced the concept of transdisciplinarity. Five empirical case studies provide data about the interrelationship between the interdisciplinary and impact or knowledge exchange aspirations of Research Council UK (RCUK) investments. We find evidence that, to an extent, UK research funding policy is achieving some elements of transdisciplinarity in practice, if not in name.

Drawing on broader debates about the limitations of knowledge mobilisation and the challenges of conducting interdisciplinary research, we reflect on how the situation has changed since our original 2004 paper. The evidence suggests that the absence of the 'transdisciplinary' label is not necessarily impeding the framing of research funding schemes oriented towards societal issues. Nevertheless, several areas where capacity-building is required, including training for early career interdisciplinary researchers; improved research leadership skills; and the capacity to evaluate the quality of transdisciplinary processes and to learn from such evaluations, are identified.

1   Introduction

Transdisciplinary research has been described as a form of extended knowledge production [1] where a variety of internal and external drivers prescribe different versions of transdisciplinary practice [2]. While acknowledging that definitions vary with cultural contexts [e.g. 3-5], we take the broad view that transdisciplinarity is characterised not only by interdisciplinary integration but also by the involvement of non-academic stakeholders in the research process, in part to address the 'applicability gap' identified by Lawrence and Despres [6]. Some theorists distinguish transdisciplinarity as collaborative knowledge generation between researchers and stakeholders; in other cases, collaboration is broadened to include consideration of the experiences of those people affected by the research [5]. Approaches that seek to involve potential research users in order to address 'real world' problems and crosscutting 'grand challenges' have become increasingly common in the research agendas of both national and supra-national funding bodies [e.g. 7-9].

Many scholars have previously offered detailed definitions of the terms 'multidisciplinary', 'interdisciplinary' and 'transdisciplinary' [e.g. 55, 57] and have sought to encourage a more consistent adoption of the nomenclature [52]. What is clear is that there is still no consensus on these definitions [54] despite a debate stretching back over 40 years [56]. Without wishing to revisit these scholarly discussions, it is worth stating that, in this article, we distinguish between 'interdisciplinarity', which for us is usually characterised by collaboration and the integration of concepts and methods (and in turn may lead to the creation of new concepts and knowledge) and 'transdisciplinarity' which takes this a stage further and may represent a different kind of knowledge production, embracing both scientific and other types of knowledge and characterised by a focus on applied research and the involvement of a broader range of expertise, including potentially the end users of such research. However, many would consider that both interdisciplinarity and transdisciplinarity share some similar research processes and indeed many, within the UK research community at least, might use the terms in a rather unreflective and interchangeable fashion[1].

While we support the thesis of this special issue that transdisciplinarity is still not mainstream and is rarely supported *per se* by funders of research, this article investigates the extent to which UK research policy has embraced the concept of transdisciplinarity, in practice if not in name[2]. We present research evidence from five empirical case studies, supplemented with a small number of additional interviews with key informants, to assess whether there is an interrelationship between interdisciplinary and impact (or knowledge exchange)[3] aspirations.

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[1] Some may even substitute the terms 'multidisciplinary' and 'interdisciplinary' although we, ourselves, are quite clear that the former represents merely a juxtaposition of disciplines without any interchange or integration.

[2] Hence the reference in our title to the quotation from Shakespeare 'That which we call a rose by any other name would smell as sweet' (*Romeo and Juliet*, Act II, Scene ii).

[3] These terms, which will be very familiar to British readers, are explained in the following section.

These twin foci on research that both crosses disciplinary boundaries and reaches out beyond the academic world might suggest that UK research policy has embraced the concept of 'transdisciplinarity' even though this is not a term that is current within policy circles. We explore the utility of the concept of transdisciplinarity and the perception that institutional constraints impede the implementation of transdisciplinarity (see Editor's introduction, this issue) within a research system that apparently addresses the component processes of integration and knowledge exchange as separate activities.

Other leading commentators have posited the resurgence of 'intervention science' [10] and our own experience as researchers and evaluators suggests that we need to look more deeply at the debate about the lack of institutional incentives for the implementation of transdisciplinary enquiry and knowledge exchange. This leads us to consider what benefits there might be if UK research policy were to embrace the concept of transdisciplinarity more explicitly.

Our earlier article [20] looked at the potential for transdisciplinary research to break down the distinction within research programmes between researchers and stakeholders from industry or civil society and was couched in terms of 'user engagement' as a way of broadening the mind since strong interdisciplinary proposals are often seen to be those that are designed in close collaboration with potential users (not least because this can permit access to research data, research subjects or additional funds). However, we also counselled that it would be wrong to assume that users will automatically have a better understanding than academics of the 'real world' nature of problems since user communities might have only a partial understanding of what their problem is and, in certain cases, might compromise the quality of the research and even lead it in unproductive directions. We highlighted the need for a clear plan for user engagement given the different exigencies and concerns of stakeholders and researchers.

Our previous contribution [20] found disappointingly few projects within the EU Framework Programme 5 that seemed, by our criteria, to be clearly interdisciplinary, let alone transdisciplinary. Subsequent Framework Programmes focused less on interdisciplinarity but, with the launch of Horizon 2020, we appear to have come full circle with a renewed interest in integrative approaches, recognising that they are key to addressing societal concerns.

1.1   The UK research system

In the UK, seven government institutions, known collectively as Research Councils UK (RCUK)[4], are responsible for investing public money in research[5]. RCUK disburses around £3 billion p.a. in research grants and supports around 50,000 researchers including doctoral students and research staff. These seven councils fund research and training activities in different areas of research (arts and humanities, social sciences,

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[4] www.rcuk.ac.uk

[5] In addition, a number of philanthropic or charitable organisations also disburse research funding in the UK, among the most notable of which are the Wellcome Trust and Leverhulme Foundation, which also support research training. With their own governance structures and charitable goals, these funders are not constrained by government priorities. An interesting question might therefore be whether they have more flexibility than RCUK to fund different types of research but this is, unfortunately, outside the scope of the current study.

engineering and physical sciences, natural environment, the medical and life sciences and large-scale science and technology facilities). In recent years, RCUK has co-ordinated the delivery of a number of interdisciplinary priority areas (such as climate change) combined with related trends towards better opportunities for interdisciplinary training [e.g. 11,12].

There has been a concurrent impetus from the UK government to ensure that the research it funds leads to societal and economic impact. A series of government reviews [e.g. 13,14] exhorted research councils to increase their economic impact (with 'economic' defined broadly enough to include policy, practice, etc.) and improve public health and quality of life through the research that they fund. This pressure has increased under the current coalition government and all research councils now actively promote knowledge exchange and connectivity with users. With the launch of its impact strategy in 2010, all researchers applying for RCUK funding must now demonstrate their planned 'Pathways to Impact' (formerly known as 'impact plans') [14-17].

Impact is defined as the 'demonstrable contribution that excellent research makes to society and the economy' while the term 'knowledge exchange' encompasses 'complex and diverse activities which can deliver impact over varying timescales' (RCUK website accessed 23/01/14). Knowledge exchange ('the process') is clearly distinct from impact ('the product') but the two are increasingly elided under the term 'knowledge mobilisation' [46,47] within a research system that has come to be dominated by the UK Research Excellence Framework (REF). This national system for assessing the quality of research in UK higher education institutions now includes measures to assess the impact of research beyond the academy [18]. Many have written about the negative influence of REF (and its predecessor, the Research Assessment Exercise), which drive researchers to concentrate on discipline-focused research [e.g. 19]. This draws in broader debates about the limitations of involving users in research [20], the spectrum of roles that users can play [1] and the challenges of measuring impact [21], all of which are especially relevant in the context of transdisciplinarity.

It is noteworthy that RCUK impact plans tend to focus on achieving project-specific impacts that are not necessarily interdisciplinary while interdisciplinary research, itself, is by no means commonplace. There have been a few notable large-scale research programmes such as, for example, the RCUK Rural Economy and Land Use (RELU) programme, which is generally regarded as having achieved both interdisciplinary *and* knowledge exchange goals [10,22] and more interdisciplinary initiatives are being launched (for example, in areas such as tree health, zoonotic diseases, land use and agriculture) by both RCUK and the EU Horizon 2020 programme (H2020). These tend, however, to be under the aegis of large-scale, directed programmes of research rather than at the level of individual, responsive mode, interdisciplinary projects.

The term 'transdisciplinary' is even less visible within RCUK contexts: a search of all RCUK websites (conducted November 2013) resulted in 3,130 hits for 'interdisciplinary', 34,700 for 'impact' but only 59 hits for 'transdisciplinary'. Similarly, a search of the Web of Knowledge publications database returned only 20 publications by authors with UK addresses when searching on the topic of 'transdisciplinary' across all years (for comparison, the same search yielded 205 hits from authors with German addresses).

Nevertheless, there appears to be dawning recognition within RCUK of the potential links between interdisciplinarity and impact: at the end of 2013, the Economic and Social

Research Council (ESRC) sought to commission a study to provide an overview of the interrelationship between interdisciplinary research and impact, drawing on existing evaluation evidence to chart the effects of interdisciplinarity on research impact [60].

1.2 Structure of article

Section 2 describes our case study methodology, while Section 3 presents our secondary data analysis from the five case studies. Section 4 discusses our findings within the context of broader debates about the roles of users in research and knowledge exchange and how this might be influenced by a transdisciplinary approach. Finally, in Section 5, we reflect on how the situation has changed since our original 2004 article and use the research evidence from our case studies to question whether future research policy (in the UK and internationally) would derive any advantage from embracing more explicitly the concept of transdisciplinarity. We discuss the implications that this might have for the framing of research funding schemes oriented towards societal issues and the additional capacity building support that would be required by the research community in order to conduct such research successfully.

2 Method

In our roles as researchers, evaluators and knowledge exchange practitioners, we have conducted a number of commissioned research projects and programme evaluations on behalf of RCUK. In many cases, these have required us to assess the extent to which specific research programmes have met their objectives regarding interdisciplinary integration, thus enabling the funders to capture learning around the management and development of large-scale interdisciplinary investments. In other instances, our research sought to identify the policy and practice impacts arising from funded projects in order to develop RCUK's understanding of the types of impacts that might derive from their funded programmes and the processes by which such research impacts might be generated. These studies adopted a case study methodology using a mixed portfolio of data-capture techniques, including qualitative (focus groups and semi-structured interviews), quantitative (including online surveys), and document analysis. This type of research design can provide rounded, detailed illustrations of the programmes under study at a particular point in time in a way that recognises interactions and complexity [23,24].

The empirical research presented in this article is based on a secondary data analysis, integrating evidence from five component studies that are brought together for the first time in order to assess the extent to which an interrelationship exists between their interdisciplinary and impact (and/or knowledge exchange) aspirations and whether this might comprise, in effect, a transdisciplinary approach. These five studies were selected as exemplars of a range of RCUK investments: within the dataset we have directed schemes and programmes (where the funder issued a specific call for a certain type of proposal) versus responsive mode grants (where the applicant had free rein to submit their own topic); as well as multi-funder and single council funded initiatives. The key features of the five component studies are summarised in **Table 1**. A further five telephone interviews were conducted with senior RCUK officials and programme managers between 25 February and 4 March 2014. These interviews sought to elicit additional information from key informants about how they understood transdisciplinarity and the extent to which the term is currently used within UK research policy.

[TABLE 1]

3   Evidence from case studies

The case studies that provide the primary data for this study were developed over the past seven years although the awards studied span over 20 years. As a combined dataset they present a number of asymmetries, traversing different funding schemes evaluated under varying remits. However, because we have adopted similar analytical frameworks and employed similar methods across all five contributing studies, we feel able to draw comparisons from across the set.   Moreover, the inevitable differences in dynamics and dimensions across the case studies serve to illustrate key issues worthy of attention. The extended duration of the study period also introduces a valuable longitudinal element that highlights changes in funder and researcher motivations over time.

We devised a framework of five questions (**Table 2**) with which to interrogate the primary data in order to answer the core research question: 'To what extent has UK research policy embraced the concept of transdisciplinarity?' and this section addresses each of these questions in turn.

[TABLE 2]

3.1   Expectation of/requirement for interdisciplinarity

As discussed above, 'interdisciplinarity' has become a feature requested with increasing frequency by UK funders, particularly when they join forces to support research addressing multi-faceted issues. In this light, the Psychology response-mode grants comprise what is effectively a null set, as psychologists applied for individual-led projects within that one discipline and no prior expectations for interdisciplinarity existed. The ESRC Research Seminar Series scheme provides an interesting contrast. While it, too, is based upon individuals suggesting their own ideas for individual-led projects, the scheme overall is intended to promote networking and thus frequently supports emergence of change. When successful applicants were surveyed, over two-thirds of respondents held 'interdisciplinary research partnerships' among their objectives [26]. Interdisciplinarity was not excluded from the range of acceptable bids and indeed over a fifth of the 2009-2010 awards, for example, are listed as 'No Lead Discipline', perhaps reflecting a solid role played by interdisciplinarity by this time. Recent ESRC language for this on-going scheme makes eligibility of interdisciplinarity explicit[6].

Desiderata for all three programmes (QUEST, PACCIT and RELU) included within our dataset unequivocally included interdisciplinarity. This was an expectation even for QUEST, which alone out of the three examples, was funded by a single research council. With multiple funders, RELU had expectations of interdisciplinarity built into it from the start, although how interdisciplinarity would be developed was not necessarily

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[6] For example, the most recent call for this scheme states in the introduction that it particularly encourages seminar groups "designed to bring together leading international *researchers and stakeholders from across disciplines* to identify new research agendas or capacity-building priorities" (italics added, see http://www.esrc.ac.uk/_images/Research-Seminars-2013-14-Call-Spec_tcm8-4041.pdf).

clear at its beginning. RELU addressed this challenge, in part, through an early programme of seed corn funding to assist nascent interdisciplinary research groups to mature. The review processes for this early stage allowed learning to take place as to selection and quality criteria relevant to interdisciplinarity when later full projects were selected [29].

3.2   Expectation of/requirement for knowledge exchange and/or impacts

Aspirations for knowledge exchange or impacts have become more prevalent in all RCUK funding calls in recent years. Our evaluation of Psychology response mode grants [25] focused on grant cohorts ending in 1998, 2001 and 2004, which would have been prior to this increased emphasis on impact. Any perceived 'impacts' would have constituted a bonus above and beyond the research excellence, which would have been the sole funding criterion for those early grants.

As time has passed for the ESRC Research Seminar Series scheme, language referring to knowledge exchange/impact has certainly become more overt in lists of possible aspirations for proposed projects. For example, the latest call for proposals explicitly places value on knowledge exchange:

> We greatly value the impact of the activities we fund, appropriate engagement of research users in the seminars, and meeting the needs of users, both within and beyond the academic community…Information about the potential impacts for academic and non-academic users of the research must be included in the proposal.

> Details of how potential users of the research will potentially be involved in the concept and development stage of the proposal and the meetings of the seminar group should be included if appropriate. We also recommend explaining how the theme(s) of the seminar series are likely to be appropriate to various groups of research users and support knowledge exchange and how the outcomes of the seminars might be communicated to relevant users [30].

As a large-scale initiative in earth system science, QUEST was designed to address critical global issues and therefore of considerable policy interest. Indeed the emphasis on policy relevance drove the desire to include social sciences in the research, although often with rather simplistic ideas about communication.

PACCIT presented an interesting case as it developed through different stages, with Phase 1 dedicated to academic research, but Phases 2 and 3 attracting support from beyond the Research Councils and overtly seeking contributions to the world beyond academia through, for example, co-funded collaborations with industry, sponsored by the then UK government Department for Trade and Industry (DTI).

From the outset, RELU explicitly included knowledge exchange among its aims; hopes for contributions to real world issues were further underscored by support from the Scottish Government and the UK Department of the Environment, Food and Rural Affairs, complementing RCUK funding.

3.3   Implementation of interdisciplinarity

Unsurprisingly, interdisciplinarity was not seen in the Psychology response-mode grants. However, in the other response-mode scheme, interdisciplinarity claimed a high profile, based on commitment of individual funded Seminar Series' leaders. Interviews with award holders underscored a strong sense of personal commitment to their original

objectives and, indeed, survey responses indicate that they made real progress toward their goal of interdisciplinarity, as well as toward interactions/collaborations with research users. With two-thirds of survey respondents aspiring to 'interdisciplinary research partnerships', nearly all (96.6%) felt they had made either some or significant progress such that two thirds of the Seminar Series appearing in the survey advanced interdisciplinarity (**Figure 1**) [26, p.13].

[FIGURE 1]

Bibliometric analysis conducted as part of the QUEST study [27] suggested that the interdisciplinarity that did take place did so primarily within fields that had themselves developed through a combination of disciplines (for example, biogeochemistry). Interdisciplinarity between less proximate disciplines was much less evident. Our evaluation found that a management decision not to commission social science-oriented projects until near the end of the programme, and to cluster them all within one of the three themes, was not conducive to strong social/natural science interdisciplinarity. This contrasted with the RELU programme where each project was required to be backed by an interdisciplinary team of social and natural scientists in order to receive funding.

Our evaluation of PACCIT did not specifically explore interdisciplinarity. Nevertheless, more than half (17) of the programme's thirty projects were seen within the programme as having involved 'explicit multidisciplinary collaborations'[7] with award holders drawn from different disciplines, frequently combining social science with computing science areas [28].

Again, interdisciplinarity *per se* was not the focus of our evaluation of RELU's non-academic inputs. However, it was evident that the RELU Directorate worked hard at interdisciplinarity at both programme and project level, with review and reward criteria aligned to its consistent messages in this regard. RELU was willing to be innovative; for example, the granting of seed corn funding to allow mixed-discipline proto-groups to meet together and spend time developing common questions and problem definitions, preparing themselves for later full-proposal calls. Our earlier evaluation found that this seed corn mechanism was effective in helping to build genuinely interdisciplinary teams [29, p.31]

3.4   Implementation of knowledge exchange

Several cases of impact were identified from the Psychology response-mode grants across a number of policy domains (e.g. social policy, criminal justice) but these appeared to arise due to individual researchers' willingness to connect with stakeholders and their issues, rather than as a result of policy drivers from the funder.

Depending on the motivation, focus and drive of the individual Seminar Series award holder, many series made a point of including non-academic colleagues. Nearly three-quarters (71%) of survey respondents saw their grant as having advanced collaborations between researchers and research users. Of the over three-quarters (77.6%) of the survey respondents citing interaction or collaboration with non-academics as an objective, 91.6% saw some or significant progress (**Figure 1**).

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[7] This echoes our earlier comment that the terms 'multidisciplinary' and 'interdisciplinary' can either be conflated or, as in this instance, the former can sometimes be seen as a precursor to the latter.

While the QUEST programme's work on modelling may have contributed to policy, the programme did not have explicit drivers toward knowledge exchange (although the motivation of many of the individual scientists was to impact on real world problems).

In contrast, the co-funding arrangements and the very framing of the overall PACCIT programme (and perhaps particularly the requirements for stakeholder involvement in projects proposed for Phases 2 and 3), appeared to drive implementation of knowledge exchange. Several PACCIT projects gave rise to divers sets of impacts from developing games software for educational and creative use to developing financial 'e-advice' products: as one informant from the closely-related Human Computer Interaction (HCI) field noted 'HCI people just naturally assume you are working with stakeholders'.

RELU's Directorate and programme-wide efforts added value, directly as non-academic impacts/influence and also through 'interactive value-added' enhancing the capacity of constituent projects to generate impacts. Through its own actions and its requirement that projects show stakeholder engagement as well as interdisciplinarity throughout the course of their work, the RELU programme created a distinctive culture oriented toward addressing stakeholder issues.

3.5   Interplay between interdisciplinarity and knowledge exchange

We have considered both funders' requests, for example, in published calls for proposals, and researchers' implementation, as evidenced by evaluation data, in assessing possible interplay between interdisciplinarity and knowledge exchange.

Within the ESRC Psychology evaluation, the only point at which interdisciplinarity arose was in the case study developed of a particular Psychology Department selected due to its multiple instances of knowledge exchange and/or impacts: that particular department and its parent university appeared favourably inclined toward collaboration across sub-disciplines of psychology, and indeed across other disciplines, in order to address user needs.

Also thought-provoking was the co-occurrence of interdisciplinary and knowledge exchange objectives among leaders of ESRC Seminar Series when asked to identify which one goal best described their own grant's most important objective (**Figure 2**) [26, pp12-13].

[FIGURE 2]

While there seemed to be an implied assumption in the QUEST programme that the inclusion of social scientists in an otherwise natural science oriented programme would result in knowledge exchange with, for example, policy communities, this was not strongly borne out by our findings.

Across the phases of its 'lifetime', PACCIT was expected to deliver academic research in its first phase and (along with academic excellence) collaboration with prospective users in later phases. In addition to its academic objectives, the programme sought to encourage the application and exploitation of research into more effective IT systems and products, to expand collaborations between researchers and the commercial and public sectors, and to disseminate new understandings to users and choosers of

systems [31]. 'Multidisciplinary research' was an explicit goal in the first phase but the sense of its usefulness seemed to continue on into later phases of working with stakeholders. Social science input may have been relatively new to some of the technology industry stakeholders; entry of technology into other domains such as education may have been facilitated by social science understanding. By the end of the programme, the word 'interdisciplinary' appeared to have entered into discourse to describe some of the work done, as well as 'multidisciplinary'.

RELU's 'bundle' of objectives explicitly brought together interdisciplinarity and knowledge exchange in a research programme designed to explore complex, multi-faceted issues. Throughout its nearly ten-year duration, RELU consistently brought together interdisciplinarity and impact when it described itself, its goals and context on its website:

> Rural areas in the UK are experiencing a period of considerable change. The Rural Economy and Land Use Programme aims to advance understanding of the challenges caused by this change today and in the future. Interdisciplinary research is being funded between 2004 and 2011 [extended to 2013] in order to inform policy and practice with choices on how to manage the countryside and rural economies (www.relu.ac.uk/about)

Our evaluation found evidence that this dual aim was deemed by researchers and stakeholders to have been achieved: all (100%) Programme Stakeholder, 91.7% Researcher and 76.4% Project Stakeholder respondents agreed that RELU's emphasis on interdisciplinarity had enhanced the capacity of RELU researchers to deliver usefully integrated understanding relevant to stakeholder problems. Nearly all (94.5%) Researcher respondents also agreed that 'RELU's emphasis on interdisciplinarity has enhanced the capacity of RELU researchers to engage with stakeholders having different perspectives' [22, p.33].

Furthermore, on a broader canvas, this explicit linkage between aims was found to be one of RELU's significant legacies which had been influential in the research and science policy arenas, particularly in the growth of acceptance of interdisciplinarity in policy-relevant research [10] and in a shift from a model of 'knowledge transfer' to two-way 'knowledge exchange' [22].

4   Discussion

Real world problems do not exhibit in disciplinary portions and, as Kogan et al. [32, p.12] note, 'science might be asked to meet the needs of society, or government, for information or conceptualisations of a kind that are not easily reconciled with its own structure of disciplines'. Similarly, van den Hove [33] calls for science and policy interfaces that allow for genuine (as opposed to tokenistic) interdisciplinary interactions between the social and natural sciences. In our introduction, we noted the current dual approach adopted by RCUK, which is increasingly encouraging both interdisciplinary research and knowledge exchange within its funding schemes. To an extent, the evidence presented by our case studies (summarised in **Table 3**) indicates that, within specific RCUK investments, a degree of both interdisciplinary research and effective knowledge mobilisation is being achieved and that, moreover, in some cases we are seeing a mutually-supporting interplay between the two trends. Indications are that RELU, in particular, and to a lesser degree some of the projects within the Seminar

Series and the PACCIT programme, did demonstrate the potential of RCUK-funded initiatives to deliver on these two interlinked goals even though neither funders nor the participants involved referred to this phenomenon as 'transdisciplinarity'.

[TABLE 3]

Furthermore, one of RELU's legacies was a conceptual impact on research funders themselves, since it provided a demonstration of the potential for a programme to be interdisciplinary and to promote knowledge exchange such that measurable impacts did occur as a result of the research funding. In actuality, this may represent a conceptual step taken toward funders having increased expectations of 'transdisciplinarity' in future from (at least) large-scale, co-funded investments even if those funders do not currently frame their goals as such.

Achieving impact from individual, single discipline, responsive mode research projects (of the type exhibited within our Psychology case study) may often be more challenging. It is now well accepted that direct impacts on policy, for example, can be difficult to demonstrate [e.g. 34,35] and simple linear models of innovation rarely occur [36]: impacts may depend on identifying the appropriate research question (ideally with stakeholder input) and the timing of research results, as well as how the results are communicated. Natural sciences (perhaps particularly biological and physical sciences) may develop innovative applications that are difficult to appropriate into practice or unacceptable to publics. The 'Pathways to Impact' documents, written for a specific research council, do not always readily accommodate knowledge exchange contributions from those outside of the main discipline, which might be considered the purview of a different research council. In a further complication, social scientists who are brought into a natural science project to facilitate public engagement may reject such a 'service' role as inimical to their approach to research [37].

Nowotny [38] suggests that, '[I]f joint problem solving [with non-academic stakeholders] is the aim, then the means must provide for an integration of perspectives in the identification, formulation and resolution of what has to become a shared problem'. A number of different knowledge exchange mechanisms designed to foster impact are currently promoted by RCUK (including the new Impact Accelerator Accounts[8] granted to research organisations rather than individuals). In some respects these may go some way to providing the 'means' but in the majority of cases, these are separately funded schemes and not an integral part of the programmes/projects that formed our case studies. They are broadly divided into (i) sharing of knowledge through closer contact between researchers and users; (ii) co-funding initiatives between research councils and users (primarily industry) and (iii) encouraging public engagement activities.

In addition to the large-scale, co-funded programmes already discussed, several initiatives seeking to bring about closer contact through exchanges of staff exist. Examples of exchanges with policy communities include the Centre for Science and Policy at Cambridge University (CSaP)[9] policy to academia fellowships and the Economic and Social Research Council (ESRC)[10] and Natural Environment Research

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[8] www.esrc.ac.uk/collaboration/knowledge-exchange/opportunities/ImpactAccelerationAccounts.aspx
[9] http://www.csap.cam.ac.uk/
[10] http://www.esrc.ac.uk/funding-and-guidance/collaboration/knowledge-exchange/opportunities/placement-fellowships.aspx

Council (NERC)[11] placement schemes put academics into policy environments, and more rarely, vice-versa. The Research Councils support a range of schemes for placing academics into industry, including Knowledge Transfer Partnerships sponsored by the Technology Strategy Board[12]. Temporary 'brokerage' roles are fulfilled by NERC's Knowledge Exchange Fellowships and the RELU Programme used short-term work-shadowing[13] as part of a knowledge exchange mechanism [39].

Placement Fellowships that embed an academic researcher in a policy or industry context (or more rarely, vice-versa) for a period of a few months tend to reflect the disciplinary background of the individual researcher involved, often a single discipline. Similarly, Knowledge Exchange Fellowships provide temporary knowledge brokering activities and tend to be in the area of the researcher's own science. Co-funding mechanisms, (e.g. industry sponsored studentships, industry clubs, industrial partnerships etc.) similarly tend to be linked to specific research projects and therefore expected to involve primarily mono-disciplinary researchers, sometimes in multi-disciplinary teams, except where they are funded across research council boundaries (for example, the sustainable agriculture industry club funded by BBSRC and NERC). Nevertheless, it may be possible for individuals with multiple disciplinary capacities to achieve a degree of transdisciplinarity by interacting with policy or industry actors who are working within the context of a multi-dimensional, practical problem.

We would suggest that the impetus for improved impact from academic research *is* driving initiatives towards a more transdisciplinary approach to research in the UK but this raises a number of questions: when does engagement and dialogue with interest-holders go beyond effective knowledge exchange and become the type of 'co-production' typically exhibited by the best examples of transdisciplinary research? And is the current UK policy focus on 'Impact, innovation and interdisciplinary expectations'[14] a sufficient indicator of a commitment to transdisciplinarity?

The continued emphasis on impact and knowledge exchange does depend upon the on-going willingness of policy makers and industry actors to commit their increasingly pressurised time to engage with a range of researchers. Ironically, there is a real danger of creating 'engagement fatigue' by seeking to secure co-design of research projects at the early proposal stage, within a competitive environment where 80% or more of such projects fail to be funded. A possible consequence is that practitioners will only work with a few trusted individuals with whom they are familiar, leaving potentially useful avenues of research under-utilised.

How can funders then act in order to foster a context conducive to effective transdisciplinarity? Two possible routes could usefully be developed further: (i) improved collation of existing research across research council activities within a specific problem area; and (ii) combining this knowledge brokering with integrating research in ways that drive research in transdisciplinary directions.

Both are needed and are exhibited to an extent in some of our case studies within a context where there is increasing awareness of the importance of research fields that

[11] http://www.nerc.ac.uk/site/guides/policymakers/placements.asp

[12] http://www.innovateuk.org/deliveringinnovation/knowledgetransferpartnerships.ashx

[13] http://www.relu.ac.uk/funding/WorkShadowsVisitingFellows/workshadowing.htm

[14] http://www.esrc.ac.uk/funding-and-guidance/applicants/iii.aspx

study the process of research itself [40]. Behaviours that promote implementation need to be better appreciated by funders. So, for example, if we understand 'brokering' as activities concerned with spreading information, generating new links between organisations and creating the basis for new operations [41], and 'integrating' as driving and directing R&D activities (rather than simply collating information and sharing data between scientists), then this also highlights the central role to be played by entrepreneurial and visionary leaders in implementing key processes [42] as demonstrated by several of our case studies. This places a responsibility on funders to select suitable research leaders and to recognise that their strengths may differ from those of more conventional academic researchers accustomed to operating within only one discipline. By whatever name, transdisciplinary activities need to be led purposively by individuals who appreciate, and are committed to enacting, the processes involved.

5   Conclusions

In the intervening decade since our previous article [20], greater emphasis has been placed by research funders on the importance of being more explicit about enhancing knowledge exchange to achieve more 'socially robust knowledge' [38] in ways that are more participatory or that put researchers on a more equal footing with other stakeholders, such as during the co-production of research [40]. While such an approach is clearly becoming more pervasive in the UK, we have demonstrated that, even using our somewhat loose definition of the term compared with other contributors to this issue and elsewhere [e.g. 57], 'transdisciplinarity' has not yet entered common parlance within UK research policy. However, the phenomenon is clearly recognised by those who use synonyms such as 'participatory interdisciplinarity' [43] or 'action research', for example.

In the UK we are certainly witnessing a growing trend toward cross-funder support for academic research, with RCUK joining forces with other government agencies and external stakeholders to fund research programmes that address interdisciplinary (or at least multi-disciplinary) challenges. This is taking place within a policy context (dating back to at least the 1993 White Paper [49]), where the UK Treasury increasingly demands measurable (non-academic) impacts from research, such that these co-investments typically appear to be motivated by, and directed toward, complex issues confronting society[15]. Funders are thus increasingly calling for the two goals that together, we argue, constitute core features of transdisciplinarity.

This is evidenced among the case studies we have investigated where we have found elements of transdisciplinarity in practice if not in name. This may go some way to countering (and indeed explaining) the perceived low level of funding attributed to transdisciplinary projects by agencies and institutions (see Editor's introduction, this issue). Given that RCUK funding has resulted in some research exhibiting both interdisciplinarity and knowledge mobilisation, does it matter that the term 'transdisciplinarity' is so seldom employed?

Pohl [44] identifies four features of 'ideal' transdisciplinarity which:

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[15] It should be noted that this has not occurred without an accompanying debate about the importance of maintaining disinterested research values (see, for example, [50, 51]).

- relates to socially relevant issues
- transcends and integrates disciplinary paradigms
- involves participatory research
- and searches for a unity of knowledge

Other theorists use the issue of how collaboration is managed and who is involved in this process to distinguish transdisciplinarity from other cross-disciplinary research approaches; another key aspect is the need to integrate different epistemologies, using different bodies of knowledge and their methodological approaches to critically reflect on one another in a transformative process [5]. This may suggest that espousing a more overtly transdisciplinary approach could have the effect of strengthening RCUK's current cross-council commitments to interdisciplinarity and impact.

It is possible that addressing the goal of transdisciplinarity explicitly would raise awareness among researchers of the potential for a close connectivity between integration of diverse academic perspectives and diverse stakeholder perspectives; perhaps a 'higher order' of integration and co-production of knowledge than hitherto achieved. However, as we have demonstrated, 'transdisciplinarity' as a term is unfamiliar to most UK funders and researchers and, with the notion of research impact still relatively embryonic in many fields, attempting to institute another new term and concept could prove problematic. One senior research funder whom we interviewed (who is personally comfortable with the term 'transdisciplinarity'), finds that it does not 'travel' as well as other terms such as 'co-creation' and 'cross-disciplinary working' when conversing with other funders. On a practical level, another funder interviewee reported extremely infrequent use of the term and no common definition; he foresaw that it would be 'quite an uphill task' to get reviewers to make that distinction if transdisciplinarity were to be an explicit selection criterion. Yet another funder who also reported that the term was rarely used, even in the RELU programme, commented:

> 'We are not suffering at present from the lack of use of the term; we are now able to talk to one another … As research funders, we now have much more experience at working together at and across interfaces between funders, both within Research Councils and between Research Councils and government departments, and in terms of engaging stakeholders.'

Senior RCUK officials agree that transdisciplinarity is being funded without the term being used explicitly:

> 'We are probably doing similar things to people [research funders] in other countries, and they may be calling it "transdisciplinarity" '.

What, then, are the future prospects for long-term change when instances of transdisciplinary-type activities, however promising, are still the exception rather than the norm? The evidence (from these UK funders, from the Horizon 2020 programme, and from our case study data and interviews) suggests that the absence of the 'transdisciplinary' label is not necessarily impeding the framing of research funding schemes oriented towards societal issues. Nevertheless, since many of the constraints operating against such research emanate from academic research systems that still discriminate against interdisciplinarity then, as a community, we do need to consider the implications of cultivating transdisciplinary capacity [45] and to address the criticism that the perceived lack of a shared conceptual framework for transdisciplinary research

militates against cumulative knowledge production (see Editor's introduction, this issue).

Moreover, in our experience, there remains, in some academic circles at least, an unspoken hierarchy of research. Despite the current policy and funding drivers for 'interdisciplinarity and impact', there is still clearly a perception that more applied forms of research are not as 'scholarly' as theoretically-driven research. While we have not explored in this article some of the more conceptual connotations of transdisciplinarity (such as the search for 'a unity of knowledge' [44]), if some of these more philosophical aspects of the transdisciplinary approach were to be made more explicit, then transdisciplinary research might achieve a greater status within UK universities.

In concluding, we cite four areas where further capacity-building is required. First, more explicit leadership training is needed for research leaders tasked with leading major, publicly-funded research investments that seek to achieve both interdisciplinary and knowledge exchange goals (whether or not they overtly aspire to 'transdisciplinarity'). Secondly, at the other end of the career ladder, the increasing emphasis on the value of interdisciplinary research in the UK has not yet been sufficiently matched by an appropriate focus on interdisciplinary (let alone transdisciplinary) research training for early career researchers [58]. Our third area relates to the issue of 'engagement fatigue' (section 4) and the need to improve the ways in which research funders co-ordinate and communicate among themselves and their stakeholders. Finally, further consideration still needs to be given to the research community's capacity to evaluate the quality of transdisciplinary processes and to learn from such evaluations [59]. A decade on from our original article [20], evaluation by peer review of proposals and publications remains a contentious area [e.g. 3,5]. Moreover, if we strive for a culture of continuous improvement, we need to understand that evaluation processes can achieve more than accountability [48, p.6], they can also facilitate development (thus helping to strengthen future programmes) and deepen cumulative knowledge production (in this case, by producing a better understanding of the component processes of interdisciplinarity and knowledge mobilisation). Research funders and research managers in the UK and elsewhere therefore have the opportunity to learn from international experience and provide judicious leadership in order to exploit the potential societal benefits of a transdisciplinary approach to research, regardless of how it is actually branded.

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A rose by any other name? Transdisciplinarity in the context of UK research policy

Table 1: Description of contributing case studies

Title	ESRC responsive mode grants in Psychology [16]	ESRC research seminars series[1]	Quantifying and Understanding the Earth System	People at the Centre of Communication and Information Technologies	Rural Economy and Land Use
Abbreviation	ESRCPsych	ESRC Seminars	QUEST	PACCIT	RELU
Main funder(s)[17]	ESRC	ESRC	NERC	ESRC, EPSRC	BBSRC, NERC, ESRC
Duration	Cohorts ending in 1998, 2001, 2004	Since 1991	2003-2011	1999-2006	2004-2013
Budget	Data not available	750 awards, 1991-2011@£15-18k, now raised to £30k	£23m	£8.4m	£24m
Published objectives relative to interdisciplinarity and/or knowledge exchange and impact	All responsive mode grants must now address ESRC's impact, innovation and interdisciplinary expectations but this was not a funding condition of these grants at the time they were awarded	There has been a long-standing expectation of innovation, at some level. Today, the call for proposals includes 'We would particularly encourage seminar groups designed to bring together leading international researchers and stakeholders from across disciplines to	QUEST's primary objective was a better qualitative and quantitative understanding of large-scale processes and interactions in the Earth system, especially the interactions among biological, physical and chemical processes in the atmosphere, ocean and land, and their implications for human	PACCIT sought to encourage the application and exploitation of new research insights in the development of more effective IT systems and products, by supporting projects which involved commercial or industrial collaborators on the assumption that better-designed IT products should lead to a growth	RELU's three core objectives were: - to deliver integrative, interdisciplinary research of high quality that will advance understanding of the social, economic, environmental and technological challenges faced by rural areas and the relationship between them

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[16] These were not time-limited programmes, but continuous schemes to fund individual projects in response to applications from researchers (hence 'responsive mode').

[17] BBSRC Biotechnology and Biological Sciences Research Council; NERC Natural Environment Research Council; EPSRC Engineering and Physical Sciences Research Council.

		identify new research agendas or capacity-building priorities.'	activities	in the market and increased uptake by wider constituencies of users In so doing, it sought to expand the network of research collaborations in the people and IT domain between the research base and the commercial and public sectors	- to enhance capabilities for interdisciplinary research on rural issues, between social, natural and biological sciences -to enhance the impact of research on rural policy and practice by involving stakeholders in all stages of RELU, including programme development, research activities and communication of outcomes
Website	www.esrc.ac.uk/funding-and-guidance	www.esrc.ac.uk/funding-and-guidance	quest.bris.ac.uk	No longer available	www.relu.ac.uk
Source of primary data	[25]	[26]	[27]	[28]	[22]

Table 2: Analytical framework

1. Was there an expectation of/requirement for interdisciplinarity? (If so, how was it called for/proposed/selected)
2. Was there an expectation of/requirement for knowledge exchange and/or impacts (If so, how was it called for/proposed/selected)
3. To what extent was interdisciplinarity implemented and achieved (as assessed in evaluations)?
4. To what extent was knowledge exchange implemented and achieved (as assessed in evaluations)?
5. Was the interplay between interdisciplinarity and knowledge exchange explicit (for example, in the call for proposals)?

Table 3: Summary of case study findings

	ESRCPsych	Seminars	QUEST	PACCIT	RELU
1. ID expected?	-	-	+	+	++
2. KE expected?	-	-	-	+	++
3. ID implemented?	-	++	+	+	++
4. KE implemented?	+	+	-	+	++
5. Interplay between ID & KE?	-	+	-	+	++

Key: - Not found; + Found to some extent; ++ Found to a great extent